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AGRICULTURAL ENGINEERING

DECEMBER 1943

The Conditions in a Two-Story Insulated Poultry House *Otis and White*

Grassed Waterways for Handling of Runoff from Farm Areas *C. E. Ramser*

Effect of Fluctuating Temperatures on Frozen Foods *Hustrulid and Winter*

The Development of a New Implement for Mole Drainage *Barr and Turnbull*

The Curing of Hay in the Mow with Forced Ventilation *Koontz, Mitchell, Dickerson*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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AGRICULTURAL ENGINEERING

Established 1920

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EDITORIAL

Breeding Black Markets

WE MAKE no pretense to such wisdom as would iron out the difficulties innumerable arising from an attempt at a rationed and regimented economy; indeed, we wonder more and more whether there can be any such wisdom. From our contacts with farm people we can, however, contribute one principle pertaining to black markets in products originating in agriculture.

Farm people are perhaps a trifle less mercenary than people at large, and in economic battle would rather fight by law-abiding than by law-evading means. But they also seem to have a keener sense of personal justice and inherent honesty. They need but little policing to pursue policies whose fairness and good faith are self-evident. Per contra, they resent edicts or enactments which do not measure up to that ethical standard, and sometimes they regard it their sacred duty to resist such measures even as did the embattled farmers at Concord and Lexington.

War does not wipe out the ethical and economic concepts of our people, and we mean particularly farm people. It would seem wise therefore, in all war expedients to make both substance and form of such expedients fit the convictions of farmers, in so far as they affect farmers. To this we may add a thought derived from the so-called "noble experiment" and sustained by more recent observation.

In general it is bad policy to enact a law, or proclaim a quasi-law, which by its very violation creates a profitable industry. Among the law-abiding it diminishes respect for the law. Among others it develops power, economic and otherwise, which is detrimental in diverse and devious ways. Observance of these principles will help to minimize black markets; to flout them is to breed black markets.

Now That the Horse Is Gone

TO US it is no surprise, though still a matter of regret, that the ceilings on farm prices and labor costs are cracking in dozens of places. The naive notion that it would be sufficient to sit on the ceiling, with no regard for the forces brewing below, was foredoomed from the start and is destined to be increasingly futile.

Now we come to the proverbial point of locking the stable after the horse is stolen. It is not too late, however, for a lock in the form of controlled costs to help protect the cow and chickens. As for the horse, we should be about the business of recapture.

It is too late to check at the source the excess purchasing power, now exerting its pressure in perhaps sixty million pockets, which is proving itself an irresistible force against the ceilings. It is not too late to recapture from those pockets that portion of purchasing power which is a principal cause of our troubles and the major force toward inflation. We mean that part of income which consists of war profits, and by war profits we mean any and all income which individuals have in material excess of their prewar incomes, regardless of its source.

Volume of demand for consumer goods, and resultant pressure on prices, come not from the rich who now feel poor, but from the poor who now feel rich. The rich are too few for either their money or their mental state to make much difference. Our national problem is a hundred million poor people who are not so poor as they were, and not quite so poor as they should be for safety in the present state of affairs. Improving their earnings and enhancing the blessings those earnings can buy is the special business of the engineer, but it is a business to be done in peacetime by actual efficiency, not in wartime by fiscal finagling.

If these problem people, the poor who feel rich, would invest their excess profits in war bonds and hold them for the rainy days to come, it would go far to solve price inflation questions now and alleviate future hardships; and this whether those hardships be borne by themselves or shifted once more to those patient "rabbits" (previously mentioned on this page) who may be expected to bear the burden when we revert from the regime of WPB to that of WPA. To be sure, many if not most of them are ten-per-centers, but what percentage of that ten per cent persists past the sixty-day non-redeemable period probably takes only a fraction of their excess expendable income.

As we have previously urged, and as now becomes more imperative, the fair and practical way to strike at the root of this many-branched problem is to apply the principle of excess profits to personal incomes. We would not apply it to such drastic degree as now destroys up to 90 per cent of the incentive for economy by big business and is itself a powerful force for inflation, particularly as regards the costs of the war. A fraction of that figure would be sufficient to raise considerable revenue, and reduce considerably the economic pressure on prices. Its most useful effect would be to restrain the feeling of being rich and thereby abate the prevailing squander-lust.

Mails Must Go Through

PROPOSALS to increase certain postal rates arouse our apprehension, but not the reasons which might logically be ascribed to a publisher. So far as has come to our notice there is no threat to raise the special low second-class rate whereby this and other scientific journals are subsidized. We would gladly forego this minor advantage as part of a program to put postal service on a basis of efficiency and sound economics.

What perturbs us is the brazen candor with which the proposed increases are put forward as a mere taxing mechanism. The postal system already is being used in a host of ways related and unrelated to its presumed purpose, namely, the movement of mails. Peddling of bonds and the collection of taxes by sale of "use" (now more properly non-use) stamps for vehicles may be worthy enough in themselves but they should not be tolerated so long as they divert man power from prompt and accurate handling of the mails. To regard postal rates in terms of general revenue is to obscure still further the light that should guide the postal system.

Possibly members of our profession encounter more than their share of errors and delays in the delivery of first-class mail. If not, and their experience is typical, then an immense number of man-days is being wasted by delays in the movement of instructions, specifications, decisions, etc. No doubt it is largely by effort to evade these uncertainties that the telephone and telegraph wires are being overloaded.

We suggest as an operating policy that the postal service concentrate on moving and delivering the mail; as a fiscal policy that it be kept free from taint of taxation and that all classes of service, including that furnished to federal departments and agencies, be charged for at rates commensurate with the costs of such service.

Conditions in a Two-Story Insulated Poultry House

By C. K. Otis and H. B. White
MEMBER A.S.A.E. FELLOW A.S.A.E.

PROVIDING a warm dry house for poultry during cold weather is a problem that confronts all poultrymen in a northern climate. The heating plant of the poultry house consists in most cases of the birds that occupy it. This type of heating plant is equipped with a humidifier of large capacity that cannot be regulated independently of the temperature. Although high relative humidities of themselves have not been known to be detrimental to poultry, the presence of large amounts of moisture in the air does cause difficulties indirectly in the building. Wall surfaces that are cold enough to fall below the dew point of the high humidity air soon become covered with condensation that may run down the wall or be absorbed by the wooden wall or framing. If the wall temperature falls below the freezing point of water, frost is formed on the walls.

Thus it is found that increasing the number of birds in a poultry house to raise the temperature may increase the difficulties with wet walls and litter. By insulating the walls and ceiling of the house well, the heat losses through the walls can be reduced. This permits the temperature within the building to increase without increasing the number of birds. The same amount of moisture added to the inside air which is at a higher temperature with insulation than without provides a lower relative humidity and a higher dew point of the air. The insulation prevents the inside wall surface from getting as cold as before and moisture is less likely to condense on it. Furthermore, cutting down the heat loss through walls and ceilings makes it possible to increase the amount of ventilation without cooling the air to a point where it becomes uncomfortable.

Since a poultry house is generally a low building, natural ventilation must depend on difference in temperature between the inside and outside of the building for success. Other ways of meeting the moisture problem are by artificial heat that permits a high temperature with only a few birds and by mechanical fan ventilation that assures sufficient air change without the necessity of a large temperature difference between the inside and outside of the building. The latter has the disadvantage in cold weather of having a cooling as well as a drying effect.

Selection of Location. To study the insulated poultry house it was decided at the Minnesota Agricultural Experiment Station to make a study, in the field, of a house that was being used primarily for the production of eggs.

An opportunity afforded itself when it was found that a group of two-story insulated houses were being used at Anoka, Minnesota, in a hatchery and egg business. This opportunity was inviting also because of the increasing interest in the two-story building for housing poultry. No data are available with regard to conditions of temperature and humidity in the second story in comparison with those of the first.

There were a number of reasons why this location was chosen for the study, among which were the following: (1)The house was well insulated; (2) the ventilation system was essentially window ventilation regulated by raising and lowering a sailcloth-covered frame over an opening in the front of the house; (3) trapnests were used in the two pens studied and careful egg records were kept; (4) it was possible to get two pens of birds, one on the first floor and the other on the second floor directly above, of the same breeding although they were from different hatches about two months apart; (5) it was close to the highway assuring access to the house in all kinds of weather; and (6) it was close to the University of Minnesota campus.

Description of the House. A picture of the house in which the data for this report were obtained is shown in Fig. 1. This is a multiple-unit poultry house 160 ft long and 28 ft wide. It is made up of four sections or units with two pens, an upper and a lower, in each unit thus accommodating eight separate pens.

Doors were cut in the west end of the house after the winter records were obtained and before the summer studies were begun. The owner decided that the building had been too warm the previous summer and consequently provided this additional ventilation. Fig. 2 shows the west end of the house after these changes had been made.

In Fig. 3 are shown the floor plan and some of the construction details of two units, or one-half, of the house shown in Fig. 1. It will be noted that in the middle of the house is a feed and work room 12½ ft wide from which all of the pens are served. One outside door serves two pens on each floor. There are two sets of such doors in the house, one for each floor on each end of the house. These doors are actually located in the end pens and there take the place of an additional window in each of the center pens. Droppings are removed through these doors and the small platform accommodating the seecond floor door permits of dumping the droppings directly into a wagon box or manure spreader. The floor litter is thrown out of the large ventilating opening at the middle of each pen.

The single outside door in the middle of the large house is for entry into the feed and work room. In this room is the stairway by means of which the second floor pens are reached.

The house was built with 14-ft studs and ¼-pitch roof. The framing was 2 x 6 balloon construction with studs and rafters 24 in on centers. The 6-in wall and attic spaces were filled with dry soft-wood planer shavings. The outside sheeting was 6-in drop siding; the inside was 28-gauge corrugated galvanized sheet steel. The first floor was concrete and the second floor two thicknesses of 1 x 12-in shiplap with sisalkraft paper between, on 2 x 8-in joists. The roof is 1 x12-in roof boards and wooden shingles. Two pens 28 x 36 ft in size and adjacent to center service room were studied.

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C. K. OTIS (at present on leave with the U. S. Naval Reserve) and H. B. WHITE are staff members of the division of agricultural engineering, University of Minnesota.

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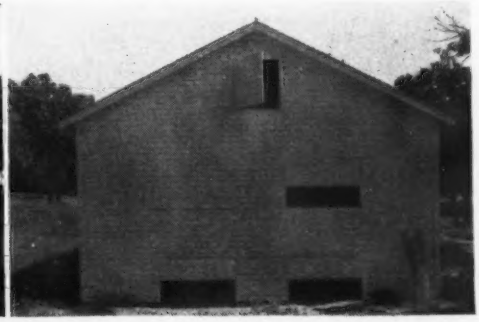

Fig. 1 (Left) The two-story poultry house used in the Minnesota study • Fig. 2 (Right) West end of house showing doors for summer ventilation

One was on the first floor and the other directly above it on the second floor.

A view of the interior of a second-story pen is shown in Fig. 4. This shows the location of the nests, roosts, and droppings boards. It also shows the corrugated galvanized sheet steel covering on the ceiling. The instrument shown at the top of the post was used for recording temperatures in two different places. The instrument on the lower side of the post recorded humidity.

A close-up inside view of the three middle windows in each unit is shown in Fig. 5. Ventilation in the winter is accomplished by manually raising and lowering the large center panel.

Ventilation and Temperature Control in Winter. In winter all the doors on the west and north sides of the house are closed as well as the windows on the south side with the exception of the large center sash which is covered with sailcloth in each pen which is adjusted manually to provide the necessary ventilation consistent with outside temperatures. Openings for ventilation in the second-story ceiling are also closed for the winter. When these are closed they are covered with vapor-proofed paper and shavings for insulation. Planeer shavings are also used for further insulating the doors on the west and north sides in the winter.

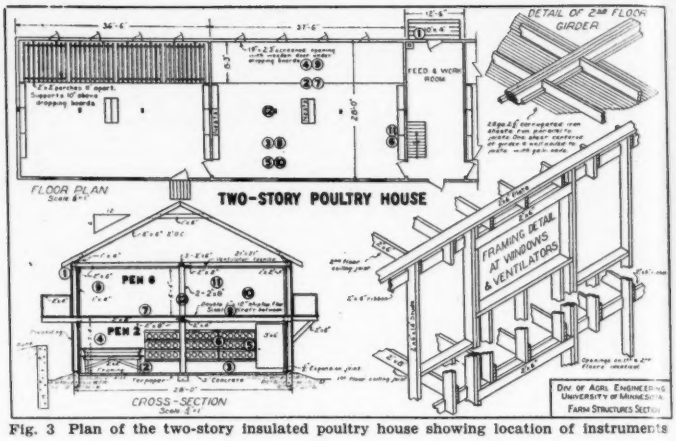

Fig. 3 Plan of the two-story insulated poultry house showing location of instruments

Summer Ventilation. Fig. 2 shows five doors in the west end of the house, two in each of the two pens on that end and one in the attic. The four openings into the pens are 19 in by 6 ft with the long dimension horizontal. They are located near the floor. Fig. 6 shows a view of the north side where there are 19 x 24-in doors that may also be used for summer ventilation.

There are no openings in the roof. Three openings 21 x 21 in in the ceiling of each second-story pen permit the movement of air from the pen into the attic and out through the door in the gable end. During the summer, windows are removed from all frames and the doors on all sides of the house are open to obtain as much circulation of air as possible. To facilitate movement of air between pens, a portion of the partition between the two pens on each end is made of poultry netting only as shown in Fig. 4. This type of partition is below the roosts as well as above. Air circulation between pens on the second floor is facilitated further by means of a screen door between the two which is on the other side of the nests. This is shown in Fig. 7.

Method of Investigation. The data reported in this paper were obtained in pen No. 2 on the first floor and pen No. 6 immediately above it on the second floor. Pens two and six are in the central section of the house and consequently have only two outside walls, namely the north and the south. Dimensions and location of equipment and facilities in each of these pens is shown in Fig. 2. Continuous daily records of winter conditions and performance were kept from December 29, 1941, to March 1, 1942. At that time there were no doors in the west end of the house. Records of summer performance were kept from August 3 to September 15, 1942. The birds housed in the pens at the time the records were obtained were hatched early in 1941. Those in pen No. 6 on the second floor were hatched in May and June and those in pen No. 2 on the first floor during March and April. All birds in both pens were of the same breeding.

Pen No. 2 on the first floor had an area of 988 sq ft and housed 450 birds which made 2.2 sq ft per bird. The roost length per bird was 8.5 in. In pen No. 6 on the second floor there are 991 sq ft and 432 birds were housed. This gives 2.3 sq ft per bird and there were 8.8 in of roost length per bird.

During the period that winter records were obtained, temperature and humidity were controlled by means of manually adjusting only the large center window during extremely cold weather and the smaller windows in addition when weather was milder. All the windows and doors were closed and partitions between pens were closed to prevent movement of air from one to the other. Window adjustments were made from time to time during the day in accordance with outside temperatures and conditions obtaining inside the house. In the evening the adjustment was set for the night and was not changed until morning.

While records were obtained in the summer all windows and doors as well as partitions between pens were open to permit free circulation of air.

Friez recording soil or distance thermographs with ten-foot capillary tubes and cylindrical bulbs were used for the temperature data on both phases and a Bristol recording hygrometer was used in the second-story pen only for humidity. A Tycos sling psychrometer was used to check humidity and an H. J. Green thermometer calibrated by the U. S. Bureau of Standards was used in setting and checking the thermographs.

The location of the instruments is shown in Fig. 2 and is described below. Each instrument was assigned a number which is shown on the figure and is carried through to the data curves.

Fig. 4 (Left) Interior view of second-story roosts and nests.

Fig. 5 (Right) (Interior view of second-story ventilating opening and windows

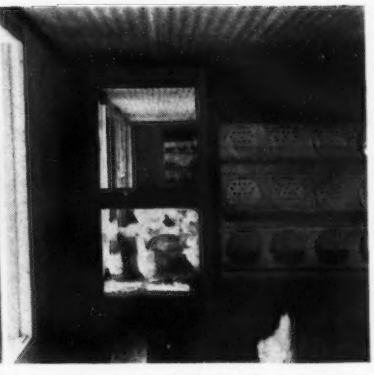

Fig. 6 (Left) North side of house showing doors for summer ventilation • Fig. 7 (Right) View of interior door, nests, and ceiling

Outside

No. 1 Thermograph on wall below eaves near middle of north side of building. A Tycos maximum-minimum thermometer was located beside this instrument as a check

First Floor — Pen 2

No. 2 Thermograph on floor under roosts near middle of pen
No. 3 Thermograph on floor near front of pen
No. 4 Thermograph about 15 in above roost near middle of pen
No. 5 Thermograph above feeders
No. 6 Thermograph in front of nests near end wall

Second Floor — Pen 6

No. 7 Thermograph on floor under droppings boards
No. 8 Thermograph on floor near front
No. 9 Thermograph over roosts
No. 10 Thermograph over feeders
No. 11 Thermograph in front of nests
Second floor instruments were located in similar positions as those on the first floor
No. 12 Hygrometer near middle of pen on second floor about 3 ft from the floor.

The instruments recorded data for the period of a week, hence the data sheets were changed once each week and the records were transferred to forms designed for that purpose. The owner of the plant kept very close dependable production records. All hens were trap-nested and egg production records were recorded hourly.

While winter studies were made, the area of window ventilating openings was also recorded hourly during the day and unchanged during the night.

RESULTS

A summary of the egg production record in each pen is presented in Table 1. While pens 2 and 6 are not strictly comparable because of the difference in age of the two flocks, the uniformly high production in both pens indicates the probability of satisfactory housing conditions.

TABLE 1. EGGS PER HEN PER WEEK

Week ending		Pen 2	Pen 6
		Winter period	
January	4	4.9	5.4
	11	4.6	5.4
	18	4.9	5.6
	25	5.0	5.6
February	1	4.9	5.4
	8	4.9	5.4
	15	4.9	5.5
	22	4.9	5.4
March	1	4.8	5.3
		Summer period	
August	9	4.53	4.60
	16	4.44	4.48
	23	4.42	4.36
	30	4.25	4.34
September	6	4.32	4.37

The conditions of temperature at the various points inside the pens, relative humidity, ventilation area, and outside temperatures are represented graphically in Figs. 8 to 12. Egg production records are also shown graphically in Figs. 8 and 11. The temperature curves in Fig. 8 represent, in the case of each pen, a composite of all of the records obtained in that pen. The *average* daily outside temperature varied from −18 to 58 F. In general the temperatures in the second story were somewhat higher than those in the first story. The average daily inside temperatures varied from 37 to 68 F in the first story and from 48 to 75 F in the second. While the inside temperature is influenced slightly by extreme changes in the temperature outside, the degree of uniformity in the temperature in both pens was remarkable.

A study of the individual curves in Fig. 9 seems to indicate that temperatures on the floor of the second story are relatively high and fluctuate considerable between day and night. Floor temperatures on the first floor are relatively somewhat lower and do not appear to exhibit the same day and night changes. Heat from the first story going through the ceiling doubtless is responsible for the effect noted on the floor of the second story. This is further substantiated by the fact that the temperature under the droppings

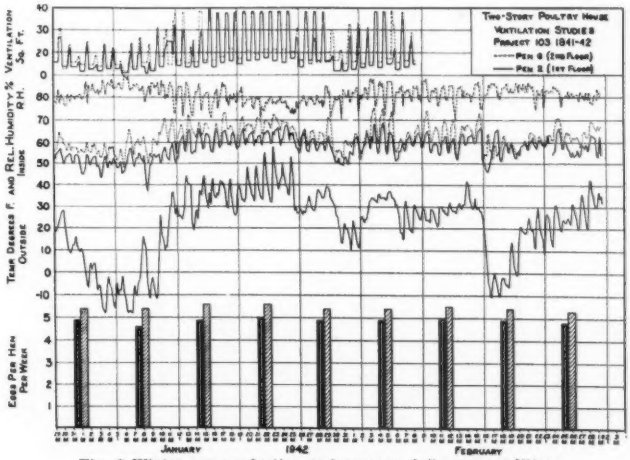

Fig. 8 Winter egg production and average daily pen conditions

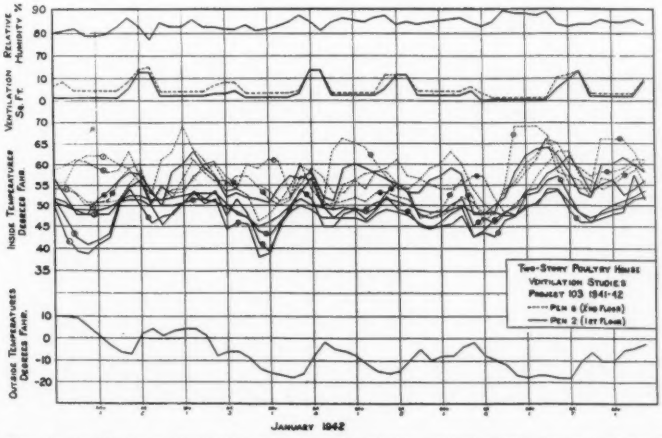

Fig. 9 Conditions in first and second stories during coldest week, January 2 to 8

boards on the second floor shows the highest rise indicating that heat has probably been trapped there.

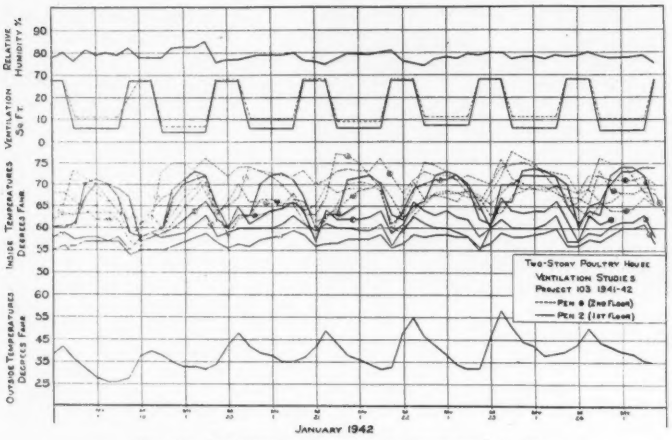

Fig. 10 Conditions of house from January 19 to 25

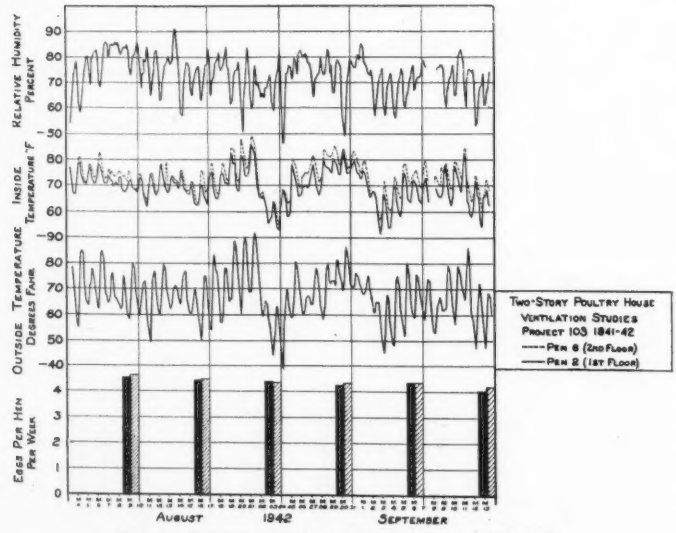

Fig. 11 Summer conditions of house and egg production

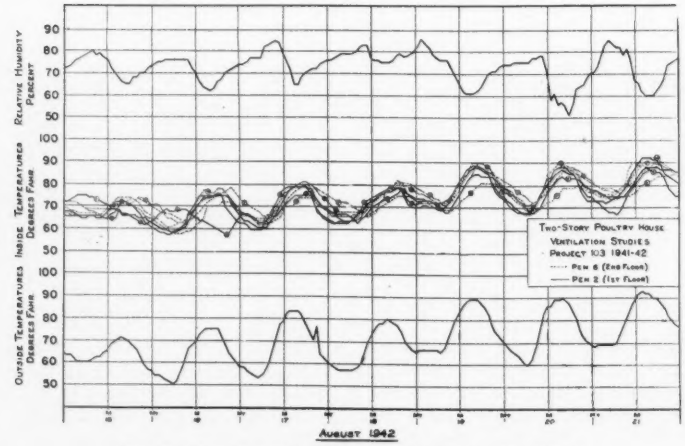

Fig. 12 Summer conditions of house from August 15 to 21

Fig. 10 indicates that during warm periods in the winter the first-story floor temperatures fluctuate very little. The temperatures at various points in both the pens are remarkably uniform.

Figs. 11 and 12 show summer conditions. Egg production was maintained at a high level about equally in both pens. Temperatures at any one time were practically the same in all parts of the house. There is shown a slightly higher average temperature in the second story than in the first story. While the range of outside temperature was 44 F during the hottest week, the range inside was 30 F.

A record of the temperatures at hot and cold periods is shown in Table 2.

TABLE 2.
TEMPERATURES AT VARIOUS LOCATIONS DURING PERIODS OF HOTTEST AND COLDEST WEATHER

Coldest Week		
Outside temperature,	maximum	+36 F
	minimum	−22 F
Coldest Hour		
Inside		
First story,	front	48.5 F
	rear	50.0
	above roosts	57.0
	at nests	49.0
	above feeder	50.0
Second story,	front	51.5
	rear	57.5
	above roosts	55.0
	above feeder	54.5
Relative Humidity		85 per cent
Warmest Week		
Outside temperature,	maximum	+94 F
	minimum	+36 F
Hottest Day		
Inside		
First story		87.7 F
Second story		89.0

These data show that the temperature reached a minimum of —22 F. This was during the night of January 3 to 4, 1942. The highest temperature during that week was 36 F which was on January 11. During the coldest hour which occurred between January 6 and 7, the lowest temperature in the house was 48.5 F and the relative humidity in the second-floor pen at that time was 85 per cent. It is interesting to note that temperatures on the second floor usually run somewhat higher than those on the first floor. Because of the failure of the instrument to function, no data are available of the temperature at the nests in the second story during this period.

The highest outside temperature during the summer was 94 F which occurred on August 21, and the minimum temperature was during the night between August 24 and 25, namely 36 F. While the outside temperature was 94 F, the inside temperature was 87.7 F on the first floor and 89 F on the second floor. These were the highest inside temperatures recorded at any period during the tests.

Since there was no frost or moisture on the walls of either pen, it was evident that the insulation was sufficient to keep the birds warm and permit of enough ventilation to remove the moisture in the air. As is usual the litter became damp and was removed about every four weeks. If litter had been more readily available, it might have been changed more often.

CONCLUSIONS

Because of the difference in age between the birds in the first-floor pen and those on the second floor, egg production records cannot be used as a means of comparing the effectiveness of conditions on one floor with those of the other. Uniformity of production, however, is a significant factor. This was maintained to a surprising degree in both pens with no appreciable difference. Thus it is evident that conditions conducive to good production existed in both pens. Records obtained indicate that both temperature and humidity were satisfactorily maintained during the

winter. It is significant that this was done without heat other than that produced by the birds. Temperature control by means of abundant insulation was probably responsible to a greater extent than ventilation for satisfactory humidity conditions. These results help to substantiate the contention that the problem of poultry house ventilation becomes simple when satisfactory temperatures are maintained by adequate insulation.

It must be concluded further that it is possible to maintain conditions on the second floor of a poultry house equally as satisfactory for production as those on the ground floor. The two-story house doubtless is practical under some conditions.

Although excellent results were obtained under conditions of manual ventilation control, it might not be possible to obtain such satisfactory results with this type of control where less attention is given to the care of the flock. Thermostatic control doubtless has possibilities for saving labor when keeping uniform temperatures.

Experience obtained while the house was being tested formed the basis for changes in the design of a poultry house of this type. Some of these are as follows: (1) The openings in the ceilings of the second-story pens were not effective ventilators, hence they are eliminated from recommended plans. (2) The width of the doors on the north side was enlarged from 2 to 4 ft.

The Home Dehydrator as a Clothes Drier

By Lawrence C. Porter
FELLOW A.S.A.E.

THE USDA program for home dehydration of garden produce, which was backed by a WPB release of materials for the manufacture and sale of 100,000 home type dehydrators, resulted in many units going into service this past summer. This program was further advanced by the thousands of pamphlets showing how to make and use dehydrators, which were distributed by various agricultural colleges.

Now that the growing season is over the owner of a dehydrator is faced with the problem of storing a relatively large cabinet until next summer. He will have little or no use for it during the next eight months, unless it can be used for a storage cabinet. Some of the dehydrated produce, particularly when it has been packaged in small bags, can be laid on the food trays and stored in the cabinet. It is possible to replace the food trays with plywood (if you can get it) shelves to enable the storage of heavier materials.

However, if the dehydrator could be used for more essential purposes than just storage this winter, it certainly would be desirable, and would help to justify the initial investment. This can be accomplished by converting the food dehydrator to a clothes drier, which really is quite easy to do.

All that is necessary is to secure some ½-in diameter wooden dowel rods and cut them to the proper length to rest on the two slides that support the top food tray. If notches are cut in these supports about 2 in apart, they will help to space the rods and keep them in position while the clothes are drying. It is not practical to dry such large things as bed sheets, blankets, etc., in the dehydrator, but most of the small pieces, such as underwear, towels, napkins, diapers, shirts, handkerchiefs, doilies, etc., can be dried easily and quickly. Rayon and nylon hose should not be put in the drier as the temperature may go high enough to injure them.

To facilitate placing the clothes on the rods, a block or a couple of straps may be attached to the top or side of the drier to hold each rod while the clothes are being placed on it. The rod is then removed and slipped into the drier on the top supports. Lower supports may be used for the shorter pieces. Fig. 1 shows a dehydrator so converted. In this particular unit the heating element is located in the back where it is quite impossible for the clothes to come in contact with it.

Even convection type dehydrators can be used for drying clothes, although it takes a little longer than it does with a fan (Fig. 2).

If the dehydrator is so constructed that the heating element is in the bottom and has no baffle above it, the lowest food tray should be left in position to prevent any possibility of the clothes coming in contact with the heater and thus becoming scorched. Tests indicate that the drier shown in Fig. 1 will dry clothes in approximately 2 hr, whereas it took three times that long when they were hung in a warm basement.

Instead of using individual rods to hang the clothes on some may prefer to make a complete little clothesrack to slide into the dehydrator, as shown with the dehydrator in Fig. 3. This unit dried the clothes in 1½ hr with the thermostat set at 135 F, and in 1 hr with it set at 185 F. When the clothes were simply laid on the food trays instead of using the rack, with the thermostat set at 185 F, they dried in 2 hr.

It was found that the use of a 15-w germicidal lamp, which emits a small amount of ozone, inside the drier imparts a slight but definite odor of outdoor freshness to the clothes.

It is obvious that the drying time will vary considerably depending upon the amount of clothes in the drier, the wattage used, the thermostat setting, the fan size, and the humidity of the outside air. However, it is conservative to say that the drying time can be reduced to one-third or one-quarter that required when the clothes are hung indoors. Whether or not the saving in drying time is worth the cost of running the unit — about 3c per hr — is something the individual users will have to decide for themselves.

Article prepared especially for AGRICULTURAL ENGINEERING.
L. C. PORTER is illuminating engineer, General Electric Co.

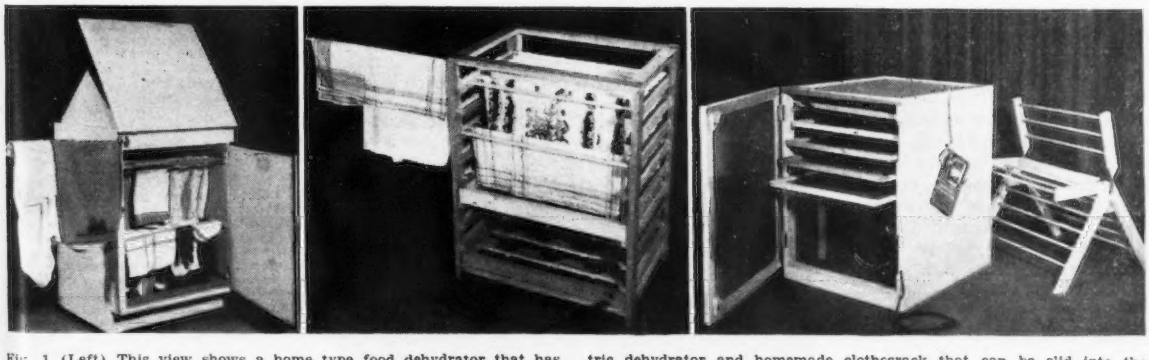

Fig. 1 (Left) This view shows a home type food dehydrator that has been converted to a clothes drier • Fig. 2 (Center) A convection type dehydrator converted to a clothes drier • Fig. 3 (Right) General Electric dehydrator and homemade clothesrack that can be slid into the dehydrator. Some prefer the clothesrack to the individual rods on which to hang the clothes

Grassed Waterways for Handling Runoff from Agricultural Areas

By C. E. Ramser
FELLOW A.S.A.E.

THE establishment of satisfactory waterways for handling runoff from agricultural areas is perhaps the most difficult problem encountered by the farmer in planning an economical and effective conservation system. This is especially true in sections of the country where terracing plays a predominant part in conservation. When I first became interested in soil conservation, about thirty years ago, not much attention was paid to the proper disposal of the runoff water in terracing work, and deep, unsightly gullies, parallel to fence lines that served as outlets for terrace systems, were a common sight. It is true that runoff water from terraces was quite generally discharged onto pastures, meadows, or woodlands, or into natural draws or depressions protected by volunteer vegetation, but cooperation by the adjoining landowner was rare which resulted in a strip along the fence lines being used quite commonly for a terrace outlet.

While vegetative or grassed natural waterways and depressions have long been employed for terrace outlets, very little use until recent years has been made of grass in artificial waterways, but dependence has been placed more on mechanical structures, to prevent such channels from developing into deep ditches or gullies. The first attempts to use grass to any appreciable extent in constructed terrace outlets were with the establishment in 1929 of the first of the ten soil erosion experiment stations. In Fig. 1 is shown a combination of Bermuda grass and low concrete check dams, 6 in high, used on a terrace outlet having a 2½ per cent slope on the first soil erosion experiment station which was established at Guthrie, Okla. In Fig. 2 is shown one of the first carefully built broad shallow grassed terrace outlets on the soil erosion experiment station that was established at Bethany, Mo., in 1930. This outlet was seeded to a mixture of lespedeza, White Dutch clover, bluegrass and redtop on a land slope of 6 per cent. Wooden checks consisting of 2 x 12 in planks buried on edge were spaced about 2½ ft vertically, the top of the plank being flush with the bottom of the channel, which served to prevent serious erosion in the channel until the grass became well established. Both of these methods for protecting waterways proved to be very effective in controlling erosion but, later, research studies tended to show that the Guthrie outlet could have been controlled satisfactorily by the use of Bermuda grass alone after a good growth became established. The concrete checks served mainly to prevent erosion during the period required for a satisfactory growth of vegetation in the channel. It has since been found generally possible on moderate slopes in most localities to dispense with the plank checks used in the Bethany waterway by building the outlet before the terraces are constructed or by diverting the flow from the terrace outlets until the grass has become well established. Such a broad shallow terrace outlet channel built without any mechanical aid and planted to meadow grasses in Virginia is shown in Fig. 3.

When these early grassed waterways were built not much was known about the permissible velocity for different grasses that were most suitable for lining such channels. In 1935 the Soil Conservation Service included in its research program a provision for the establishment of an outdoor hydraulic laboratory near Spartanburg, S. C., in cooperation with the state agricultural experiment station, one of the principal objectives being to study the flow of water in grassed and other channels used in soil and water conservation activities. A little later similar investigations were started at Stillwater, Okla., in cooperation with the state western climatic conditions. Also some studies were started on the agricultural experiment station, to study western grasses under soil conservation experiment station at McCredie, Mo., in cooperation with the state agricultural experiment station, to study bluegrass and other grasses common to the corn belt not generally adapted to the southern climate at the other two locations. While considerable information of much practical value has been collected at these locations with respect to a variety of grasses, there is still a great deal to be learned about the hydraulic performance of grassed channels with reference both to permissible velocities and retardance coefficients. A discussion of the results obtained to date will reveal the need for much more comprehensive and complete experiments to supply all field requirements. It will not be possible within the scope of this paper to discuss the experiments in detail but only to point out some of the outstanding conclusions and results, chiefly of the Spartanburg studies[1] and briefly of the McCredie experiments[2], some of the results being applicable to northern conditions.

Fig. 1 (Top) Terrace outlet protected by Bermuda grass and low concrete check dams on the Guthrie (Okla.) Soil Conservation Experiment Station • Fig. 2 (Center) Terrace outlet protected by a growth of mixed grasses consisting of lespedeza, white Dutch clover, bluegrass and redtop on the Bethany (Mo.) Soil Conservation Experiment Station • Fig. 3 (Bottom) Broad shallow terrace outlet built without any mechanical aid and planted to meadow grass in Virginia. Terraces have been extended across small ditches on each side used to carry the water until a good stand of meadow was established

PERMISSIBLE VELOCITIES

Results of Experiments at Spartanburg, S. C.

The studies at the Spartanburg outdoor hydraulic laboratory included extensive experiments in Bermuda grass, common lespedeza, lespedeza sericea, and a mixture consisting of redtop, orchard grass, common lespedeza, and Italian rye grass. A few tests were run on Centipede grass, Sudan grass, and Crab-Dallis grass mixture. A series of experiments pertaining to seasonal conditions and growth were conducted on channels

[1]The Spartanburg experiments were conducted by F. B. Campbell, W. O. Ree, and V. J. Palmer. The manuscript for a bulletin covering these experiments in detail has been prepared by Messrs. Ree and Palmer.

[2]The McCredie experiments were conducted by D. D. Smith.

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with kudzu. For vegetal-lined channels, which are subject only to intermittent flows, the element of time becomes important in establishing permissible velocities. For flows of short duration some scour can be permitted since slight erosion will usually soon heal over. Accordingly the permissible velocities recommended may result in some erosion but not sufficient to damage the channel during the usual short periods of flow. In making these studies it was found insufficient merely to run tests for green condition of vegetation since the permissible velocity for most grasses is less for dead, dormant, or cut condition.

Bermuda Grass. Permissible velocities determined for Bermuda grass for dormant and green condition and for long and short growth are given in Table 1.

TABLE 1

Condition	Land slope, per cent	Permissible velocity ft. per sec.
Long, green	up to 10	8
Long, green	10 to 20	7
Short, green waterway kept cut short	up to 10	9
Short, green, mowed just before testing	up to 10	6.5
Long, dormant	up to 10	8
Long, dormant	10 to 20	6
Short, dormant	up to 10	6

With regard to tests on short grasses it is necessary to distinguish between two types of short grass, long grass that has just been mowed before the tests, and grass that is cut frequently to keep it short. The latter has more resistance to erosion as is indicated from the permissible velocities given in Table 1. The results also indicate that green Bermuda grass is only slightly more resistant to erosion than the dormant grass.

Common Lespedeza. While waterways are usually planted to perennial vegetation, the annual common lespedeza is often used, particularly in meadow-type outlets seeded to a grass mixture. Accordingly considerable testing was performed on this lining. Experiments were conducted on the green uncut, fall dead stubble, spring dead stubble, and cut stubble. Common lespedeza is grown as far north as southern Pennsylvania and New Jersey.

A study of the scour rates obtained on the test of common lespedeza lining showed that the green uncut lining offers a fairly good protection to waterways. The permissible velocity for the vegetation in this condition is about 5½ fps. A test on the channel made in the spring on the dead stubble lining was that in this condition it offers very little protection to the channel. At this time of the year the dead plant has rotted at the base and is very easily broken off by the flowing water. The permissible velocity for a lining in this condition is approximately 1 fps. In the fall, however, the protective ability of dead stubble is much greater and it was found that the permissible velocity in this condition was about 4½ fps. The tests which were made on the stubble that remained after cutting the vegetation are rather surprising. A velocity of over 7 fps caused very little damage in the channel. The low permissible velocity for dead stubble in the spring is certainly a weakness in the use of common lespedeza alone for protecting waterways. However, when seeded with grasses including orchard grass, Italian rye grass, and redtop, it plays a very important part in making an effective channel lining.

Lespedeza Sericea. Lespedeza sericea is a perennial legume which has found wide use in the Soil Conservation Service program. It has been employed extensively as a lining in a meadow-type natural waterway where a mixture of grasses is used. When lespedeza sericea was in a green woody state considerable scour took place in the channel, and the scour was somewhat higher for a dormant uncut lining. The results of the experiments seem to indicate that the permissible velocity for dormant uncut lining should be approximately 2½ fps and that for the woody green lining 3 fps on a 6 per cent slope. For the green uncut lining which has not reached a woody stage, the permissible velocity is about 5½ fps on a 3 per cent slope. For dormant short and dormant long lining the permissible velocity is 3 fps and for green short lining 3½ fps on a 3 per cent slope.

Grass Mixture. Where outlets are grazed a mixture of plants may be desirable. In addition to providing a better pasture a mixture may provide a better channel lining. If the plants have different periods of flush growth and dormancy, a better year-round protection will result. A number of tests were conducted on a mixture of redtop, orchard grass, Italian rye grass, and lespedeza. Orchard grass and redtop tend to grow in heavy clumps. Without other grasses or vegetation between these plants, the flow over such a lining tends to be rather rough and irregular. When the depths of flow are large enough to submerge entirely the plants and stems of the grass, these irregularities will be somewhat drowned out. When other vegetation is growing between the clumps producing a more uniform cover, a much more satisfactory lining results. This mixture of grasses and lespedeza offers good all-the-year-round protection for the channel. The tests on the uncut grass made in June did not result in high enough velocity to cause any appreciable scour on the channel bed. However, on the basis of experience with grass linings, it is believed that a permissible velocity for this grass mixture in the summer and for the short grass lining in the fall should be about 6½ fps. In the early spring when the grasses were dormant and the new lespedeza seedlings had not yet appeared, the Italian rye grass was green and offered good protection to the channel. For a lining in this condition the permissible velocity is 5 fps. It is believed that the Cornell utility mixture would be equally satisfactory for use in waterways. It consists of timothy, redtop, Kentucky bluegrass, Canada bluegrass, Mammoth red clover, Alsike clover, and Ladino clover.

Centipede Grass. Centipede grass is a heavy sod-forming grass adapted to the Southeast. Since it can compete successfully with other vegetation and at the same time can be eliminated easily by plowing, it offers promise as a substitute for Bermuda grass for channel linings. This grass being rather short is seldom mowed so no tests were run on the cut condition of the grass. The permissible velocity for green condition was 9 fps and for dormant condition 8 fps for a slope up to 10 per cent. Unfortunately this grass cannot be grown successfully farther north than South Carolina.

Sudan Grass. Sudan grass is a rapidly growing annual and as such is particularly adapted for lining waterways where the flow cannot be diverted and a rapid establishment of the cover is important for temporary protection until perennial grasses are established. It is not regarded as a permanent lining. An objection to the use of Sudan during dry years is that it crowds out any permanent vegetation seeded with it so that the channel has very little protection after the Sudan dries or is harvested, and it is difficult to establish a permanent vegetation for protection before the following spring. The results of experiments indicate that the permissible velocity on a Cecil sandy clay loam is about 4 fps for a full-grown green lining and about 3 ft for a dead lining on a 3 per cent slope. This would be too high for a young growth of Sudan grass for linings in light sandy soils. It is grown successfully as far

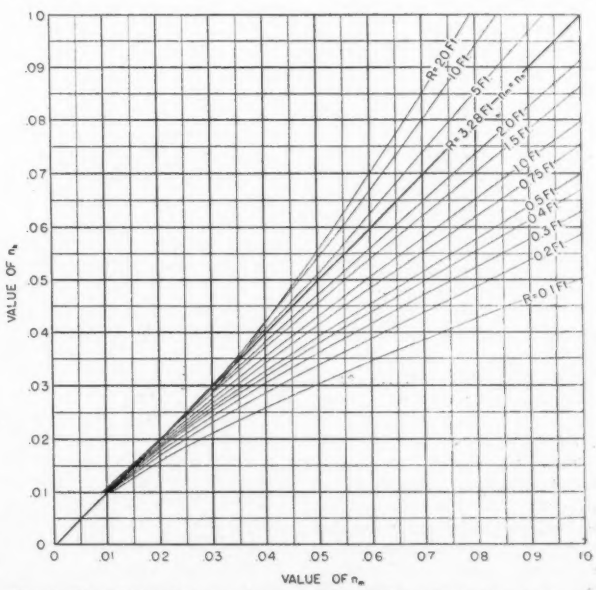
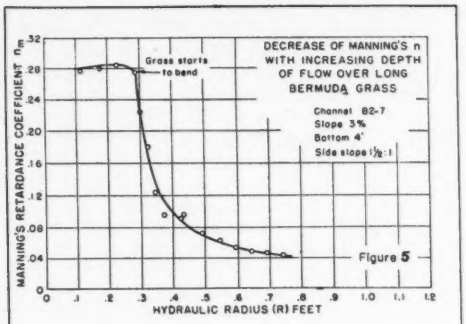


Fig. 4 The relation between the retardance coefficient n of Manning's and Kutter's formulas


DECREASE OF MANNING'S n WITH INCREASING DEPTH OF FLOW OVER LONG BERMUDA GRASS
Grass starts to bend
Channel B2-7
Slope 3%
Bottom 4'
Side slope 1½:1
Figure 5
MANNING'S RETARDANCE COEFFICIENT n_m
HYDRAULIC RADIUS (R) FEET

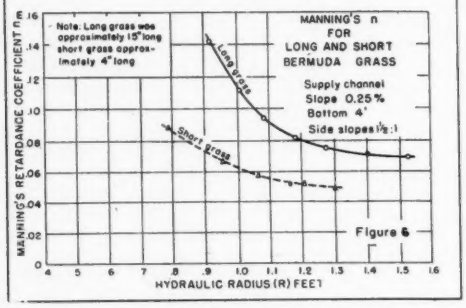


Fig. 5 (Above) Variation of values of Manning's n for increasing values of the hydraulic radius

Fig. 6 (Below) Relationship of Manning's n to hydraulic radius for long and short Bermuda grass

north as the northern boundary of South Dakota.

Crab-Dallis Grass. It was originally intended to test Dallis grass as a channel lining. Due to a poor stand of Dallis grass a volunteer growth of crab grass appeared and since this is a condition that might occur in field channels, the experiment was continued. Compared with other grass mixtures, this mixture offered rather poor protection to the channel. It was found to have a permissible velocity of about 3½ fps on a 6 per cent slope. Dallis grass is adapted only to southern conditions.

Kudzu. Kudzu is a perennial vine characterized by prolific growth and dense foliage. It is best adapted to climatic conditions in the South but grows as far north as Maryland. It is particularly adapted for use in large natural waterways or gullies where reduction in cross sections due to heavy growth is not objectionable. It was found to have a much lower protective ability than any of the vegetation tested. Permissible velocities on a 3 per cent slope for various conditions of lining tested are about as follows: Live, heavy growth uncut, 4 fps; live, heavy growth cut, 3 fps; dormant heavy growth uncut, 2½ fps. These velocities are recommended only for good covers in channels free from sharp changes in grade, alignment and cross section. For less favorable conditions including sandy soils, these velocities should be reduced. The test on a dormant vegetation showed that the loose mulch consisting of dead leaves, stems, and vines has very little protective ability against concentrated channel flow.

Experiments at McCredie, Mo.

So far satisfactory tests have been run on only two grass linings at McCredie, Mo., namely, Kentucky bluegrass and a timothy and redtop mixture. It was found that the permissible velocity for a one-year-old poor stand of Kentucky bluegrass seeded on a 4 per cent slope was only 3 fps. The second year, however, for a good two year-old stand the permissible velocity increased to 7 fps. Kentucky bluegrass sod withstood a velocity of 15 fps on a 20 per cent slope without appreciable damage. This seems to indicate the superiority of sod over seeded grasses particularly before the grass has become well established. A one-year-old stand of timothy and redtop mixture withstood a velocity of 7 fps on a 4 per cent slope and the permissible velocity for a two-year-old stand was found to be the same. From this it is seen that there was very little difference in protection against scour between one and two-year-old mixed timothy and redtop. Also that one-year-old bluegrass was inferior to one-year-old timothy and redtop in preventing scour, whereas two-year-old bluegrass was equal to or superior to two-year-old timothy and redtop.

* * * *

In considering the foregoing recommended safe mean velocities for tests at Spartanburg and McCredie, it should be remembered that the test channels were carefully constructed and were free from irregularities in shape, slope, or alignment and that the lining was in good condition. The velocities given above must be reduced for channels of non-uniform cross section as well as for regular channels in which the density of the vegetal cover is substantially less than that of the linings tested.

The experiments at McCredie were conducted on Putnam silt loam soil and at Spartanburg on Cecil sandy clay loam. For sandier soils which erode more easily, judgment should be used in reducing the permissible velocities. It should also be remembered that the channels must be carefully maintained to insure a good cover free from weeds, and any possible weaknesses such as rodent holes, stock tracks, or bare areas should be immediately repaired.

RETARDANCE COEFFICIENTS

Since waterways depend upon their dimensions and slope to handle the runoff from the tributary drainage area, it is necessary to know what effect various protective grass linings have in retarding the flow. To obtain this information it is necessary that tests on grassed channels include the determination of retardance coefficients for the different vegetation used as linings.

The retardance coefficient n for both Manning's and Kutter's formulas was determined for the tests that were made. In this discussion only the coefficient from Manning's formula will be included. It is well to call attention, however, to the common fallacy of assuming that Manning's and Kutter's n are identical. This is true only for a channel having a hydraulic radius of 3.28 ft. For small rough or irregular channels Manning's n generally greatly exceeds Kutter's n as illustrated in Fig. 4.

Results of Experiments at Spartanburg, S. C.

Bermuda Grass. When subjected to excessive flow Bermuda grass will flatten to the bed of the channel. When the flow stops, the stems will resume their erect position unless an excessive deposition of silt has occurred. When the latter occurs, Bermuda has the ability to recover its stand rapidly. These characteristics, together with the dense cover generally formed and the relative ease and rapidity of establishing a new cover, make this grass ideal for use in channels. The flattening of the grass produces a shingling effect which affords great protection to the soil surface. Also there is less disturbance and retardance to the flow than if the stems tended to remain erect. The curve in Fig. 5 illustrates the variation of the values of Manning's coefficient for increasing values of the hydraulic radius. The shape of the curve is readily understood when the behavior of the grass under flow is considered. For very shallow flows with low values of hydraulic radius the retardance coefficient is very high. For a range of values, the depth is less than the height of the grass stems. The stems and blades block out a portion of the cross sectional area and their presence in the flowing water creates considerable disturbance. The result is a high fairly constant retarding influence on the flow as indicated by the flat section at the beginning of the curve. The retardance coefficient remains constant at a high value until a stage is reached where the flowing water exerts sufficient force to bend the stems to the bed of the channel. When this occurs, a rapid reduction of the retardance coefficient results because the blocked area is reduced and the disturbance of the flow by the lining is greatly diminished.

When the retardance coefficient includes the area blocked out by the vegetation higher values can be expected for long grass than for short grass. This is illustrated by the two curves in Fig. 6 where the relationship of Manning's n to hydraulic radius for two different lengths of Bermuda grass is shown. The percentage reduction due to cutting is much greater for the shallow flows than those which are relatively deep.

The values of Manning's n for Bermuda grass at the permissible velocity for different conditions of channel and land slope are given in Table 2.

TABLE 2

Condition	Landslope, per cent	Manning's *n*
Green, long	10	.040
Green, long	20	.043
Green, short, kept mowed	10	.030
Green, short, mowed before testing	20	.046
Dormant, long	10	.039
Dormant, long	20	.042
Dormant, short, kept mowed	3	.031
Dormant, short, mowed before testing	3	.033

Common Lespedeza. Considerable variation in Manning's *n* for common lespedeza was found and, as in the case of the Bermuda grass, was due to the blocked out area and the flattening of the vegetation. The values of Manning's *n* at the permissible velocity for different conditions of channel and landslope are given in Table 3.

TABLE 3

Condition	Landslope, per cent	Manning's *n*
Green, uncut in spring	3	.037
Green, long, in summer	6	.046
Green, short, cut before testing	3	.031
Dead uncut stubble in spring	3	.100
Dead uncut stubble in fall	3	.045

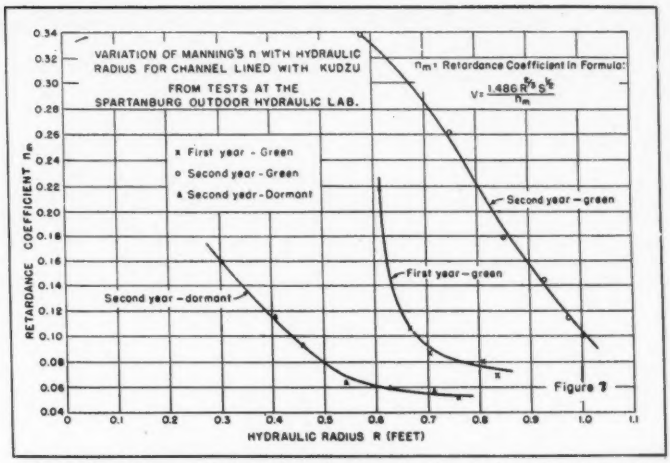


Figure 7

Fig. 7 Manning's *n* plotted against hydraulic radius from tests on three different conditions of kudzu

It is seen from Table 3 that dead uncut stubble has a very high value of *n* as well as a very low resistance to erosion which was mentioned when discussing permissible velocities.

Lespedeza Sericea. It was found from these experiments that the tall green stems of the lespedeza sericea were sufficiently pliant to bend under the force of flowing water. This produced the desired shingling effect which resulted in lower values of *n* than for dormant stems that were quite woody and resisted bending to a large degree. The values of Manning's *n* for lespedeza sericea at the permissible velocity for different conditions of channel and landslope are given in Table 4.

TABLE 4

Condition	Landslope, per cent	Manning's *n*
Green, uncut (not yet woody)	3	.058
Green, medium, (long woody)	6	.084
Green, short, (cut before testing)	3	.042
Dormant, uncut	6	.053
Dormant, uncut	3	.066
Dormant, short (cut previous fall)	3	.039

Grass Mixture. This mixture includes orchard grass, redtop, Italian rye grass, and common lespedeza. As stated before, both the orchard grass and redtop tend to grow in heavy clumps. When the depths of flow are sufficient to submerge the plants and stems of the grass entirely, these irregularities will be somewhat drowned out. When other vegetation is growing between the clumps producing a more uniform cover, a much more satisfactory lining results. The values of Manning's *n* for this grass mixture at the permissible velocity for different conditions and land slope are given in Table 5.

TABLE 5

Condition	Landslope, per cent	Manning's *n*
Green, long, (summer)	3	.040
Green, dormant, short, (spring and early summer)	3	.037
Green, dormant, short, (fall)	3	.034

Centipede Grass. Centipede grass was observed to have good hydraulic properties. The short leaves and stems about 6 in in length readily flattened out under flow and quickly straightened up again when the flow ceased. The sod formed was very dense and the cover quite uniform. The retardance coefficient showed the same variations with hydraulic radius as with Bermuda grass. The values of *n* in Manning's formula at the permissible velocity for different conditions of channel are given in Table 6.

TABLE 6

Condition	Landslope, per cent	Manning's *n*
Green, long	10	.037
Dormant, long	10	.038

There was practically no difference in the values of *n* for green and dormant conditions.

Sudan Grass. Only one experiment was run on a channel with a lining of Sudan grass. The time of testing was late fall and the grass was already dead. The stems of the Sudan grass were 2 to 4 ft in length. They were not woody and readily bended over and shingled under the force of the flowing water. Tests were made over a relatively narrow range of depths and the value of *n* in Manning's formula varied from 0.042 for a depth of flow of 0.28 ft to 0.050 for a depth of 0.42 ft.

Crab-Dallis Grass. The Crab-Dallis lining was found to have a relatively high retarding influence. The value of *n* for this channel for a 6 per cent slope was found to be 0.065 at the permissible velocity for the channel. This grass is adapted only to southern conditions.

Kudzu. The great mass of leaves and vines produced by kudzu has considerable retarding effect on the flow of water. The influence upon the retardance coefficient is two-fold, namely, the relatively large portion of cross section occupied by the mass of vegetation and the disturbance to flow offered by the vines, stems, and leaves that do not shingle like Bermuda or centipede grass. In Fig. 7 Manning's retardance coefficients are plotted against hydraulic radius from tests on three different conditions of kudzu. One of the most striking things evident in Fig. 7 is the extreme variation of the retardance coefficient with age and condition. This is readily understood when the physical characteristics of the plant are considered. The test on the first year growth yielded relatively high values of *n*. The next year resulted in still higher values. Increased number of plants and growth are responsible for the larger retardance coefficient.

It may be well to point out that the first-year growth in the channel was probably equivalent ordinarily to a good two-years' growth in a field waterway. The second-year stand probably had achieved a maximum density for this vegetation. When in a dormant state the leaves and some of the vines are dead and lie on the channel surface as thick mulch. The bulk of vegetation in the channel is considerably less than it was in the green state. Accordingly the retardance coefficient is much lower. Cutting the vegetation leaves the channel with still less cover resulting in the lowest value of *n*. The values of *n* at the permissible velocity for different conditions of channel are given in Table 7.

TABLE 7

Condition	Landslope, per cent	Manning's *n*
Live, heavy growth, uncut	3	.083
Live, heavy growth, cut	3	.052
Dormant, heavy growth, uncut	3	.071

Results of Experiments at McCredie, Mo.

The retardance of coefficient *n* in Manning's formula was determined for channels lined with bluegrass sod on slopes of 1, 4, 8, 12, 16, and 20 per cent at McCredie, Mo. With vegetation such as bluegrass the resistance to flow will vary appreciably as the velocity and depth of flow change. Shingling of the grass occurs when the frictional force of the flowing water is sufficient to overcome the maximum bending movement of the *(Continued on page 416)*

The Effect of Fluctuating Storage Temperatures on Frozen Fruits and Vegetables

By Andrew Hustrulid and J. D. Winter
MEMBER A.S.A.E.

A STUDY of the factors that are fundamental in the construction and operation of family-sized freezer-lockers for the freezing and storage of frozen foods was initiated at this Minnesota Agricultural Experiment Station about three years ago. In designing the freezer-locker, one of the first questions that must be answered is, "Is it necessary to have a separate compartment for freezing the food?"

If a separate "sharp freezing" compartment is not available and the storage compartment is used for freezing, it is desirable to reduce the temperature below the normal storage temperature each time fresh food is added in order to promote more rapid freezing. The product already frozen and in storage will, therefore, be subject to periodic fluctuations in temperature. The general opinion of research workers seems to be that such large and perhaps frequent changes in temperature would cause excessive desiccation of the stored produce and thereby lower the quality.

The purpose of this report is to give some preliminary results of our work in subjecting frozen fruits and vegetables to fluctuations in storage temperatures of approximately 20 F.

Duplicate lots of snap beans, corn, peas, strawberry, raspberry, and cantaloupe were prepared. One lot was stored in a modern locker plant at a nearly constant temperature and the other stored in our 30-cu ft experimental freezer-locker unit and subjected to fluctuating temperatures. The storage temperatures in both were 5 F or less at all times*. After a minimum storage period of six months the lots were compared as to appearance (color and shape) and palatability (texture and flavor)—the two factors most important to the ultimate consumer. Products packed in sugar or other sweetening materials were rated separately on intensity of flavor and on degree of sweetness.

All products to be eaten without cooking were judged immediately after thawing, and those requiring cooking were judged when ready to serve. The vegetables for most of the tests were unseasoned to bring out better any possible changes in flavor. The duplicate lots were placed in numbered bowls for judging with no identification as to place of storage. They were then judged independently by Miss Claire Kercher and the authors and the results averaged.

A representative record of the air temperature in the storage space of the experimental box is given by the solid curve in Fig. 1. The differential control on the thermostat was set to give a continuous fluctuation of 8 to 10 deg in the air temperature. A larger fluctuation occurred when the control was set to give a lower temperature for freezing and then set back to the regular storage temperature of approximately 0 F. The temperature for freezing was – 20 F with the freezing period ranging from 12 to 24 hr. All products tested were subjected to at least fifteen of the larger temperature changes during the storage period. The dotted curve in Fig. 1 gives the temperature at the center of a one-pound rectangular package of raspberries. The temperatures were measured with iron-constantan thermocouples connected to a Leeds and Northrup 8-point recorder.

The results shown in Table 1 indicate that a fluctuating storage temperature had no great influence on the appearance and palatability of the products checked. Meat was kept in the experimental box along with the fruits and vegetables. There was no apparent deterioration in either appearance or palatability of the meat which could be attributed to fluctuating temperatures.

TABLE 1.

Product	Lots	Storage time, months	Score out of a possible 100 Locker plant	Experimental freezer
Snap Beans	1	6	78	66
"	3	7	83	84
"	2	8	84	81
"	2	9	80	73
Corn	2	6½	86	86
Peas	2	8	86	91
Strawberries	1	7	90	91
Strawberries	1	9	87	87
Cantaloupe	2	6	89	89
Raspberries	1	7	98	95
"	1	8	99	95

As a consequence of these preliminary results, it appears that a constant storage temperature is not important if the product is properly selected, prepared, and packaged, and if the storage temperature is 5 F or less. Thus a one-compartment freezer-locker can be used satisfactorily for both storage and freezing without the product losing quality due to the fluctuation in storage temperature. This conclusion is confirmed by the experience of cooperators using one compartment freezer-lockers built and operated under the direction of the authors.

AUTHORS' ACKNOWLEDGMENT: The authors wish to acknowledge and to express appreciation for the assistance of Miss Claire Kercher in judging the product, and for the loan of the condensing unit from the Minneapolis branch of the International Harvester Company.

Article prepared especially for AGRICULTURAL ENGINEERING. Paper No. 2118, Scientific Journal Series, Minnesota Agricultural Experiment Station.

ANDREW HUSTRULID and J. D. WINTER are respectively, associate professor of agricultural engineering and assistant professor of horticulture, University of Minnesota.

*Trouble with the condensing unit allowed the temperature in the experimental unit to rise above this value once for several hours reaching a maximum of 26 F.

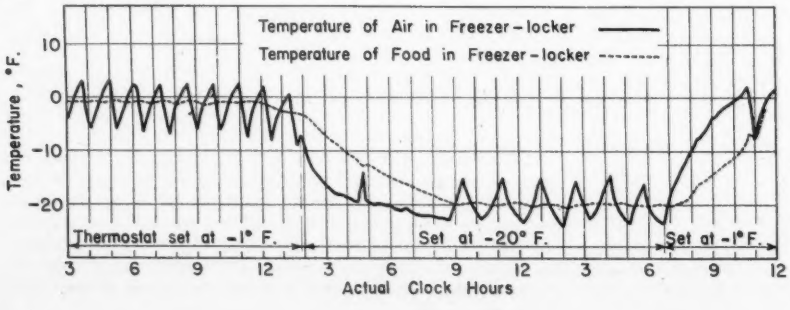


Fig. 1 A representative record of the temperatures in the experimental freezer-locker during the storage period

Grassed Waterways for Handling Runoff

(Continued from page 415)

plant stems. The action is similar to that described for Bermuda grass. The point at which bluegrass shingles depends upon a combination of factors, including velocity, slope, depth, and duration of flow.

For a depth of flow of about 9 in, values of n varied from 0.027 for a rather poor stand on an 8 per cent slope to 0.052 for an average stand on a 1 per cent slope.

Tests on Vegetated Waterways at Stillwater, Okla.

Since the grasses tested in Oklahoma with the exception of Bermuda were western grasses — blue grama, buffalo and weeping love grass — and are not adapted to northeastern conditions, they will not be discussed in this paper. These tests are published in Technical Bulletin T-15 of the Oklahoma A. and M. College.

A New Implement for Mole Drainage

By Harold T. Barr and James Turnbull

MEMBER A.S.A.E.

DRAINAGE research work in Louisiana is being carried on in the sugarcane area extending in from the Gulf of Mexico approximately 150 miles and extending back from the Mississippi River some 25 miles on each side of the river. The surface elevations vary from below sea level (this area being under levee and pumps) to 25 feet above sea level.

Generally the soils are a sandy loam near the river and bayous, and gradually change to a very heavy clay or buckshot soil on the back of the plantations or swamp sections. These soils have a gradual fall of 12 in per mile from the river back to the swamp.

The sugarcane fields are laid out in rectangular cuts with lateral ditches each 75 to 150 ft apart. The lateral ditches drain into canals which converge into a main canal leading to the swamp, bayou, or main parish drainage canal. A typical plantation drainage system is shown by Fig. 1.

On an average, 15 per cent of the labor cost for producing a crop of sugarcane goes for maintenance of the lateral ditches and small canals. Several authorities writing on sugarcane in Louisiana in the past have stated that the most important item in producing a good crop of sugarcane is drainage and more drainage. For the most part, the plantations on which the highest yields are obtained are those on which the better drainage systems and drainage maintenance are found. Even with the numerous lateral drains, many plantations still suffer from inadequate drainage. The heavy nature of the soils in the sugarcane area lead us to believe that mole drainage would provide a definite improvement in drainage conditions.

Two acres were moled in heavy Sharkey clay close to the Mississippi River levee in 1936. Four-inch moles were put in at a depth of 18 in on 10-ft centers. Little or no attempt was made to maintain the mole openings. As a result, field rats soon filled the openings and little results were obtained from this test during the following seasons.

A heavy-duty chisel or subsoiler was modified and used in installing these tests. This machine weighed 3500 lb and had no suitable method for changing the depth of the mole while in operation.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943. A contribution of the Soil and Water Division.

HAROLD T. BARR is head of agricultural engineering research, Louisiana Agricultural Experiment Station, and JAMES TURNBULL is associate civil engineer, Soil Conservation Service, U. S. Department of Agriculture.

AUTHORS' NOTE: Research on drainage is being conducted in Louisiana jointly by the division of water conservation and drainage, Soil Conservation Service, U. S. Department of Agriculture and the Louisiana Agricultural Experiment Station.

In 1942 and 1943 ten acres were moled on a commercial sugarcane plantation to obtain results under ordinary field operations. It is too soon to give any definite results. However, twelve hours after a 2.3-in rain the check area still had water standing 3 in deep in the middle of the rows while there was no water on the surface in the moled area.

Commercial mole ditchers are available which have proven entirely satisfactory for drawing mole lines. In general they are subsoiling machines with a mole-ball attachment. The most satisfactory type allows adjustment of pitch of the point and permits adjustment of depth while in operation. Like other farm machinery at the present time, the supply of these commercial mole ditchers is limited and subject to government restrictions.

In developing a mole ditcher at the Louisiana Agricultural Experiment Station, availability of materials, ease of handling, and cost were given considerable weight. The machine developed can be built of scrap metal available at most junk yards. The machine weighs only 500 lb and can be built for less than $100, including labor. It consists of two 8-in channels 10 ft long which act as skids and two 12-in channels welded vertically to act as a support for the mole beam as shown in Fig. 2. The beam is ½ x 6-in material and is 6 ft long. The beam is hinged by a pin at the top and prevented from rotating by a block held by two pins. A series of holes in the beam allow vertical adjustment from 18 to 48 in.

The most difficult part to make is the mole point. From the work we have done we find that a 3½-in pipe makes a satisfactory point. The dip should be from 1-in-4 to 1-in-5 in.

We have experimented with a number of mole points and mole beams and find that, if a 1-in beam is used with a 4-in mole, it is advisable to use a point with the maximum possible downdraft — that is, a chisel type point. If a point with less downdraft is used, the machine has a tendency to ride a few inches off the ground. This same tendency has been observed in the use of a commercial machine with a point whose pitch can be varied. If the pitch is set improperly, the whole machine can be made to ride several inches off the ground, although the weight of the machine is almost 2½ tons.

If a ½-in beam is used, the point can be made more streamlined. Whether there is any advantage to the streamlined point over the chisel point is as yet undetermined.

Fig. 3 shows some of these mole points. Mole "A" is a solid point. This was turned down on a lathe from a solid piece of 4-in shafting. It is entirely satisfactory, but the time required to make

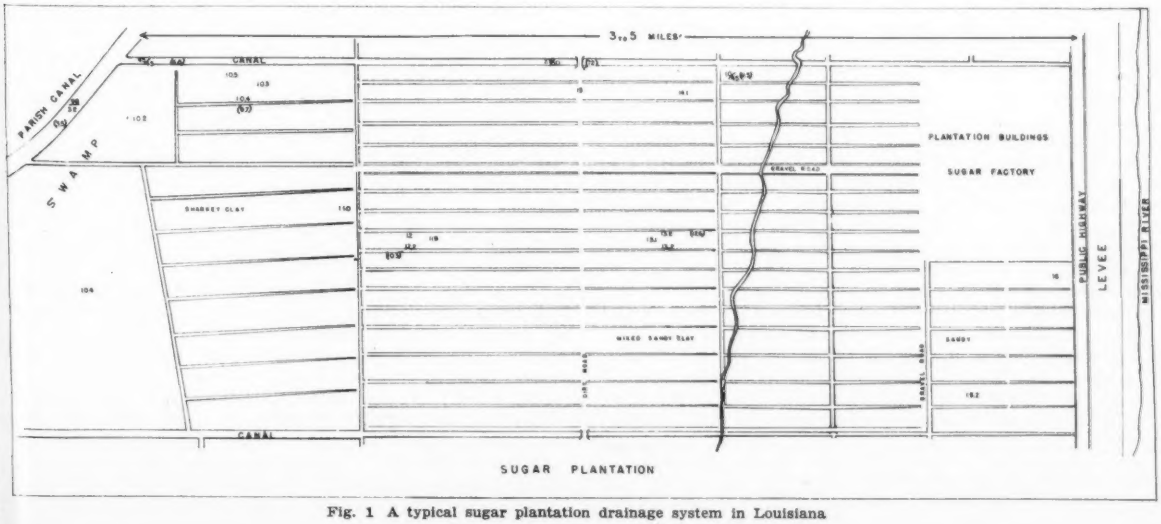
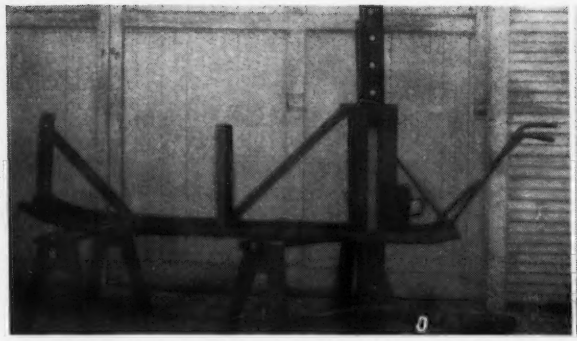
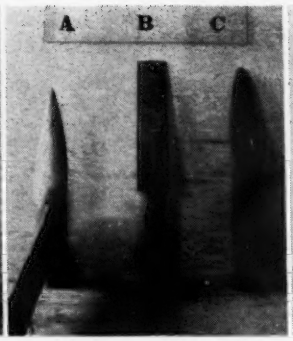


Fig. 1 A typical sugar plantation drainage system in Louisiana





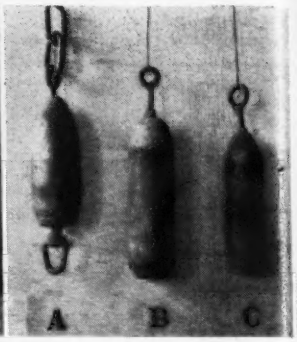


Fig. 2 (Left) This shows the mole ditcher developed by agricultural engineers at the Louisiana Agricultural Experiment Station • Fig. 3 (Center) Three of the mole points used in the Louisiana studies • Fig. 4 (Right) Three of the mole balls built at the Louisiana station

it is not justified. Mole point "B" is made of 3½-in O.D. pipe and can be made in a fraction of the time required to turn out a solid point. The pipe is cut with a slope of 1-in-5 in, slightly concave, and a piece of flat plate welded on. The inside is reinforced with two plates where it is pinned to the beams. This point has proven very satisfactory and is quite simple to make. Point "C" is similar to "B" except that the plate welded on the top is cut to fit the pipe. It too is satisfactory with a light beam.

The mole point is followed by a mole ball and several types have been built at the Louisiana station as shown by Fig. 4. All have been found to be satisfactory. Ball "A" is a solid casting. Ball "B" is made of pipe with a rounded wooden end in front. Ball "C" is similar to "B" except that the rounded point has been obtained by "orange peeling" the pipe and welding it. Balls "B" and "C" were developed to permit the use of a mole attachment for drawing a tile into the outlet of the mole and then releasing it without the necessity of stopping the tractor.

Tests with the homemade mole indicate that it will perform the job for which it was designed. Mole line up to 4 in in diameter and varying in depth from 18 to 48 in can be installed in suitable soils. The skids being 10 ft long will ride over minor depressions which might cause low spots with a wheeled machine. It is easy to remove the mole from the ground at the end of a run. Simply back the tractor enough to remove the stress on the compression block, take out the two pins, and start the tractor forward. The beam will rotate about the top pin, and the point will come up to the surface with surprisingly little disturbance of the soil. Finally, by reason of its light weight, it can be easily loaded in a pickup by two men and transported wherever required.

AUTHORS' ACKNOWLEDGMENT: The authors wish to acknowledge the assistance and helpful suggestions of Lewis A. Jones, chief, division of water conservation and drainage, Soil Conservation Service, U. S. Department of Agriculture.

Mow Curing of Hay

By J. H. Ramser

STUDIES of mow curing of hay at the Illinois Agricultural Experiment Station indicate sufficient uniformity in results to justify a progress report, although not enough tests have been made to warrant definite conclusions.

A total of eleven tests is reported here. In each case from two to three tons of partially cured hay were placed in a 14 x 16-ft experimental storage structure mounted on a platform scale. The blower was automatically controlled to operate (1) when spontaneous heating occurred in the mass of hay and (2) when the relative humidity of the outside air was sufficiently low to afford suitable drying conditions. Data were taken on air flow, temperatures, moistures, time of operation, and power consumed.

Although the tests were conducted under a variety of weather conditions and with a wide range in moisture content of the green hay, a striking uniformity was found in the rate of drying. Our data show a nearly constant decrease in moisture; with one exception a safe moisture condition was reached within seven days.

Paper presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1942. A contribution of the Farm Structures and Rural Electric Divisions.

J. H. RAMSER is assistant in agricultural engineering, University of Illinois.

Table 1 shows the higher power requirement for hay stored at moistures above the generally assumed 40 per cent optimum. At an average initial moisture percentage of 50.9, it required 21.1 kw-hr per ton of dry hay to complete the curing process, whereas at an average moisture percentage of 35.1, the power required was 12.1 kw-hr. Although this difference is not important in terms of cost, problems of dusty hay, lack of uniform curing, and condensation occurred with the high moisture lots. There was no tendency, however, for the hay to reach dangerously high temperatures when the blower was set to operate automatically.

TABLE 1. POWER REQUIRED FOR LOFT CURING ALFALFA HAY AT HIGH AND LOW INITIAL MOISTURES

Initial moisture	Average, per cent	Power per ton of dry hay, kw-hr
High	50.9	21.1
Low	35.1	12.1

TABLE 2. POWER REQUIRED FOR DRYING DIFFERENT TYPES OF ALFALFA

Kind of hay	Initial moisture, per cent	Moisture after 7 days, per cent	Moisture removed per ton dry hay, lb	Dry hay, tons	Power per ton dry hay, kw-hr	Power for 100 lb moisture removed, kw-hr
Long grassy	35.2	18	525	3.05	7.8	1.49
Long clean	31.0	20	320	2.88	7.8	2.44
Chopped	30.6	12	540	2.52	12.4	2.30
Crushed	35.0	20	464	2.07	11.6	2.50

Table 2 shows a comparison of the power requirements for chopped, crushed, long grassy, and long clean alfalfa. Weather conditions or other uncontrolled factors may have been responsible for these differences, which are not significant.

TABLE 3. SUMMARY OF ILLINOIS LOFT-CURING TESTS

Kind of hay	Blower in operation, days	Time blower operated, hr	Initial moisture, per cent	Final moisture, per cent	Power per ton of dry hay, kw-hr
Alfalfa —					
Long	7	51.5	40.6	12.7	15.8
Long	11	66.1	51.5	11.3	15.9
Crushed	10	69.5	35.0	10.0	13.6
Long	8	50.2	31.0	14.9	7.8
Long grassy	9	83.5	35.2	18.74	10.6
Long	9	110.0	50.2	18.6	20.5
Brome, and	13	178.5	38.3	9.0	16.6
Chopped	8	133.5	51.2	12.1	27.0
Chopped	9	82.2	30.6	13.0	14.9
Average (alfalfa)	9.3	91.5	40.4	13.3	15.8
Soybeans	15	252.7	54.8	17.6	38.7
	11	78.7	57.4	18.0	17.7
Ave. (soybeans)	13.0	165.7	56.1	17.8	23.2
AVERAGE	10.0	105.1	43.2	14.1	18.1

Table 3 gives the summary data for all tests for alfalfa and soybean hay. The higher moisture content and the coarser stems of the soybean hay required longer processing and more power. The reduction from 40 to 13 per cent in moisture with an expenditure of 15.8 kw-hr is regarded as typical for the alfalfa.

In virtually all cases the loft-cured hay was judged to be of better quality than similar field-cured hay. This year (1942) the department of dairy husbandry of the University of Illinois installed a full-sized dryer and obtained good quality hay during a rainy period when the hay which was cut and left to cure in the field was a total loss.

Some Results of Curing Hay in the Mow with Forced Ventilation

By L. L. Koontz, Nolan Mitchell, and W. H. Dickerson, Jr.

MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

A GREAT change is taking place in the southeastern states, not only in the kind of hay crops grown, but the acreage is increasing rapidly. According to USDA statistics, legumes such as alfalfa, clover, cowpeas, lespedeza, and soybeans comprise approximately 75 per cent of the total acreage. In Virginia the acreage of alfalfa nearly doubled during the period 1924-38. The production of lespedeza was of no significance in Virginia prior to 1931, but by 1938 its acreage was more than double that of alfalfa, and its total production in tons was about equal to alfalfa. It has been estimated that Virginia produced about 1½ million tons of hay in 1940, yet it was necessary to bring in approximately 130,000 tons from outside the state to meet its requirements.

Because of Virginia's humid climate, the introduction of legumes such as alfalfa has greatly added to the hay harvesting and storage problems. Taking advantage of the frequent rains and use of seed selection, fertilization, and good management, farmers are able to produce excellent yields of the highest quality. However, the frequent rains make it very difficult to harvest and cure the hay so as to preserve its nutritive value and high quality.

The total rainfall during any month of the haymaking season is not excessive, but consists of numerous light showers which occur at short intervals. Following is a 28-year record of average monthly precipitation and days of occurrence during the haying season as shown from weather bureau records for Wytheville, Virginia:

Month	Average number of days with 0.01 in or more rainfall	Average rainfall, in
May	13	3.6
June	14	4.3
July	15	4.0
August	14	4.1
September	10	3.2

Rainfall records collected for the 1942 season at the Virginia experimental substation at Glade Spring showed that the only period during the midseason month of July, in which hay could have been cured in the field without being subjected to rain, was July 12 to 18 inclusive. Furthermore, it rained on five of the six days preceding this period which means that the ground and standing hay were wet at the beginning of the period. In view of this, it is possible that farmers delayed cutting until July 13 or 14 or even later. Even at this time, the ground would have been quite wet, a factor that would have caused the hay to cure rather slowly in the field. Therefore, it is likely that part of the hay cut during this period was caught by the rains that started again on July 19. Yet it rained only 13 days during the month as compared to 15 days for the 28-year average.

This situation imposes a serious handicap on any farmer who depends entirely on curing hay in the field. Recent surveys indicate enormous losses in the value of the hay crop due to entire loss or damage in field curing. It should be kept in mind that when a farmer loses his hay, or has it damaged due to field curing, one of two things must take place: either his vital production drops or he must spend additional money for replacement hay or supplementary feeds.

To remedy this situation the forced ventilation method of curing hay in the barn has been developed. Based on experimental data and observations in the operation of the driers, a definite procedure has been evolved for handling hay in the field and on the driers. This procedure takes advantage of the very rapid drying of the hay in the field during the first few hours after cutting.

Mowing is started in the morning as soon as the dew is off the grass. The hay is allowed to dry about two hours in the swath and is then raked into windrows where it remains for another two or three hours. This field drying for four or five hours on a clear day reduces the moisture content of the hay to about 45 per cent before it is placed on the drier. Placing the hay on the drier the same day it is cut prevents any damage resulting from the deteriorating effects of dew, rain, or further sun bleaching.

In placing the hay on the duct system, care must be exercised to see that it is evenly distributed and uniformly packed. This has been found extremely important in getting the proper distribution of air through the hay. Best results have been observed where the depth of the hay over the ducts has not exceeded 6 to 10 ft for any one curing. After the initial layer has been dried, another may be placed on top of it and cured. For best economy and curing results the total depth of the hay should not exceed 15 to 20 ft over the ducts.

The blower unit should be operated continually during the day when humidity conditions are such that the air will absorb moisture from the hay. At night and during rainy days air is forced through the hay only as needed to prevent heating. This is accomplished by operating the blower unit one hour at six-hour intervals. By this procedure hay can be dried to 20 per cent moisture content in 7 to 14 days, depending upon weather conditions and the initial moisture content of the hay when placed on the drier. Hay with a moisture content of 20 per cent is considered satisfactory for storage.

The forced ventilation method of curing hay in the barn was introduced in Virginia in 1940, through the cooperation of the agricultural engineering department of Virginia Polytechnic Institute and the rural department of the Appalachian Electric Power Company. Three systems were installed — one on the Virginia Polytechnic Institute experimental farm at Blacksburg, another on the R. G. Stevens farm at Dublin, and the third on the I. C. Choate farm at Sugar Grove, Virginia.

Mr. Choate already had a motor which he was using for feed grinding, etc.; therefore, his only investment was in the duct system and fans. His barn is of the bank type with driveway in the center; he has only a duct system on one side of the driveway at present. However, the installation was so planned that the same fans and motor can be used when the additional duct system is installed on the other side of the driveway. Here is what Mr. Choate had to say at the end of the 1942 season: "I have used the drier system three years and I think it almost paid for itself each year. All the hay that was field cured is dark and damaged. I think I lost one-eighth of my crop that was cured in the field, while there was no waste at all in the barn curing method. I think the drier was a good investment and I have recommended it to several others who have installed the system and seem to be well pleased."

Mr. Stevens went a step farther and installed a furnace and stoker in order to supply additional heat to the air before blowing it through the hay. At the end of the 1942 season Mr. Stevens has this to say: "We specialize in alfalfa hay for sale as a cash crop and therefore use our drier only for curing that crop. We preheat the air before blowing it through the hay raising the temperature about thirty degrees. By this method we do not depend on weather conditions to dry the hay partly in the windrow before placing it in the drier. Our drier holds about ten acres of alfalfa at a time.

"We start cutting early in the morning immediately windrowing with a side-delivery rake, and follow with a hay loader and put it on the drier. By evening the entire ten acres are on the drier ready for curing. The time required to dry a batch is from 36 to 96 hours depending upon the dew or moisture in the hay, outside air temperature and humidity, etc. By use of the drier we have eliminated a 25 per cent loss in curing and molding, and by handling our hay wet we have no loss of leaves and it maintains a rich green color. In fact, the hay inside the bales when opened is about as green as when cut and for this extra hay we get $5 a ton premium. Our outfit cost us approximately $2500 and it has more than one-half paid for itself in premiums alone. We are of the opinion that

Paper presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1942. A contribution of the Farm Structures and Rural Electric Divisions. (Revised to include 1943 observations.)

L. L. KOONTZ is division rural supervisor, Appalachian Electric Power Co.; NOLAN MITCHELL is assistant agricultural engineer, agricultural engineering development division, Tennessee Valley Authority, and W. H. DICKERSON, JR., is assistant agricultural engineer, Virginia Polytechnic Institute.

the labor saved by only one handling pays for the fuel and power."

In the spring of 1941 H. P. Musser, of Charleston, West Virginia, installed a system on his farm near Salem, Virginia. After two seasons experience with the forced ventilation method he states: "There is no question about the barn-drying method making it possible to obtain a better quality of cured hay. It always has a green color due to reduced bleaching in the sun, and there are more leaves saved because the hay can be brought to the barn before shattering of the leaves takes place. Entirely aside from the question of improved quality of the barn-cured hay, probably the greatest value of the drier comes from the prevention of damage or entire loss of hay by unseasonable weather for field curing. Time and again we have been able to cut hay in small quantities in a period of continuous rain, getting the hay on the drier with only a few hours of field curing and finishing it in the barn. I cannot emphasize too strongly that curing hay in the field presents a serious problem to prevent loss, and it is of tremendous advantage to be able to put half cured hay in the barn and save it from certain damage due to unseasonable weather. Without any elaborate calculating, it has been our experience that the drier pays for itself purely as a means of preventing damage or loss due to unseasonable haymaking weather. I plan to extend facilities for further barn drying just as soon as labor conditions make it possible."

MANY ADVANTAGES OF FORCED VENTILATION

The results from the foregoing installations during 1940 and 1941 indicated clearly the many definite advantages of the forced ventilation method of curing hay in the barn for the farmers of southwest Virginia. Therefore, the information was taken to the farmers in educational group meetings early in 1942. Following these meetings assistance was given interested farmers in making layouts, advising where the proper equipment could be purchased, and supervising the actual installation. As a result the number of hay drier installations in southwest Virginia reached a total of nineteen by the end of the 1942 season. Regardless of the difficulties encountered in securing equipment, as well as the lack of promotional work, Virginia ended the 1943 season with forty-five systems. This number would have been considerably higher had it not been for the difficulties the farmers had in obtaining priority ratings from the War Production Board on which to purchase fan units and motors.

"I cured 358 tons of hay", said C. Henry Harman of Tazewell. "In my opinion and that of other farmers who inspected it, it fully doubled the value to cure the hay in driers instead of by the old field curing method. My investment in construction and machinery for the four systems was approximately $1,500. I am sincere in my opinion that the investment increased the value of my hay at least $10 per ton. I saw hay lying in the fields for a week to ten days that would have been of little value to me, and during the same time I was cutting and curing mine. I cured hay that was put into the barn with 80 per cent moisture, and the lowest moisture content of any put in was 55 per cent. It cured almost perfectly. This year was my first experience with soybeans and I was somewhat skeptical whether the drier would do an adequate job. The beans in my estimation cured perfectly. Graded in Washington, the results were U. S. No. 1. I can recommend the forced ventilation method to any farmer, and from the experience I have had in curing hay in the field, I don't know of a better investment."

Mr. Harman is a large dairy farmer. Three of his duct systems are located in one dairy barn 160x36 ft, the other in another barn 80x36 ft. He has three sets of blowers which he alternates between four systems.

Farmers on smaller dairies have also been well pleased. For example, A. L. Leffell, Shawvers Mill, wrote: "I installed this year (1942) in part of my barn a hay drying system, size 20x30 ft. The entire cost for the fan and duct system was approximately $65. Without this system I would have lost at least one-half of my hay. The quality of the hay was 100 per cent better than hay cured in the ordinary sunshine way."

J. T. Frazier of Chilhowie cut three crops of alfalfa hay from eight acres of ground. It rained almost constantly at each cutting, but he said: "I saved all of it. The labor it saved is an advantage too. Heretofore, I have always had to shock it, stack it, then haul it to the barn. This time I put it on the wagon after raking it up and put it immediately in the barn. Due to the wet weather the cost of electric current used in drying the hay was about $1 per ton. This was offset by using less labor. Since labor at that time was almost impossible to get, had I not had my electric hay drier I probably would have lost my hay."

R. G. Williams, a fruit and dairy farmer of Wytheville, said: "There is no question in my mind but that the electric drier saves hay. It saves leaves which are 50 per cent of the value of the hay. They would be lost in sun curing. The drier was put in a barn which was not convenient for us to reach, so it was operated by a hired man who had no experience with a hay drier. We got some good cured hay anyway, which could not have been done by the field method."

The good hay Mr. Williams referred to in his letter turned out to be U. S. No. 1 alfalfa when graded by the USDA. He plans to install another system at one of his other barns as soon as he can secure the equipment.

"The hay drier is one of the very best pieces of equipment I have ever had on my farm", says Wm. N. Mebane, Dublin, Va. " It has more than paid for itself the first season. I cut 18 acres of alfalfa that I believe I would have lost if it had not been for the drier, as it rained nearly every day and we could not have gotten it in between showers. The fall of water was not excessive as a whole, yet it was enough to make the hay heat without the drier; but I succeeded in curing the entire lot and it has made excellent hay. I cured 60 to 75 tons of beautiful hay that would probably have been lost or very seriously damaged. The cost of the installation was very moderate and the cost of the current was not at all excessive."

G. C. Umberger, Marion, Va., wrote: "I cured the equivalent of 22 acres on the drier. We were having quite a lot of rain, and I feel it would have been impossible to have saved this hay without the drier. I put a few loads of the hay on the drier right after a shower, not placing it too deep in any one place, and found it dried out perfectly. I find by comparison that I have a much brighter green, a more leafy, better quality of hay from the drier than some alfalfa that was field cured under ideal conditions. I feel that regardless of weather conditions the electric barn hay drier is a good investment from the standpoint of the better quality of feed you get from it."

WOULD HAVE LOST HAY CROP WITHOUT DRIER

W. H. Smith, Pulaski, Va., said: "This barn-dried hay is better in every way than field-dried hay that I have cured before. It was green in color and extra leafy and of course was not bleached by the sun. I would have lost the better part of my hay crop had it not been for the drier. In particular, my entire crop of soybeans would have been lost. I am sure that in one season alone my drier has more than paid for itself. In addition to saving hay in a rainy spell, the hay goes further in feeding stock and it is richer and more leafy."

"Taking into consideration the farm labor shortage I feel that it is of great importance to every farmer to take advantage of all means available for the better care of his crops", wrote Gordon C. Felts, Galex, Va. "I am greatly pleased with the operation of my drier and the quality of hay it can produce. I find I have a much better grade of hay than when field cured. It helped me save hay that otherwise would have been lost." Mr. Felts practices what he preaches as he installed two additional hay drier systems in 1943.

The lack of man power and transportation made it impossible to keep records on the 1943 installations. However, the records on cost for the 1942 installations showed a range, depending on size of system, from $80 to $350. This included lumber, blower unit, labor, electrical materials, pulleys, belts, and one-fourth the value of the motor. Since the motor can be used for a number of other farm jobs, only one-fourth of its value was charged directly to the hay drier. Analysis of the cost records showed that the average cost of installation varied between 15 and 20c per sq ft of mow area.

Records on 1005 tons of hay showed an average of 53 kw-hr per dry ton. A considerable amount of this hay was placed on the driers with rather high moisture content. Alfalfa, clover, timothy, mixed field grasses, soybeans, lespedeza, barley, oats, and rye were successfully dried. It was observed that better results were obtained where the air flow was 10 to 15 cfm or more per sq ft of mow area.

Thirty-three samples of hay were sent to the USDA for grading and classification at the end of the 1942 (*Continued on page 422*)

Prevention of Rust in Farm Machinery

By R. I. Shawl
MEMBER A.S.A.E.

ONE of the serious machinery problems facing the American farmer today is the rusting of his machinery, much of which stands out-of-doors the year around due to a lack of storage buildings, or which is exposed to the weather for several months while in use on different crops. Much machinery and labor can be saved if farmers will make use of the easily applied rust preventive compounds recently placed on the market by several of the large oil companies.

Rust prevention as discussed in this paper refers to the protection from corrosion of polished and unpainted metal surfaces of farm machinery and equipment during idle periods by the use of a special rust preventive petroleum-base coating which can be easily removed when the machine is put into operation.

Extensive research has led to the conclusion that corrosion is essentially an electrochemical process, but corrosion may be defined in a general way as a chemical action resulting in the oxidation of metals caused by the oxygen of the air and water reacting with the metal to form rust. Acids and salt mists carried by the air may also cause serious oxidation.

Rust preventives for unpainted metal parts have been widely used by industry for many years, to protect parts when in storage or in transit, but only during the past year have some of these compounds been made available for retail sale in reasonable sized containers of 25 lb.

Rust preventive compounds are made by adding a rust inhibiter to a liquid or grease, usually a petroleum product. When the rust preventive has a petroleum base it can be used with safety to prevent rusting of roller and ball bearing in machines in storage because it also acts as a lubricant when the machine is again put into use.

A good rustproof compound for farm machinery should meet the following requirements:

1 Provide a protective film over the metal surface that will not crack, peel, or slip under extreme ranges of temperature and long periods of exposure to the elements

2 Prevent rusting when applied to moist surfaces and stop further rusting when applied over rusted surfaces

3 Be easily applied by brushing or diluted for spraying

4 Contain some lubricating properties if it is to be used to prevent rusting in bearings or moving parts

5 Be easily removed preferably with petroleum fuels

6 Be easily removed from hands and clothing.

When using axle grease, transmission oil, or crankcase oils to prevent rusting of machinery surfaces, the amount of protection against rust depends largely upon the viscosity and thickness of the coating. The reverse is true of rust preventive compounds, because thin films of these compounds when properly applied will give protection for quite a long period. The protection offered by these compounds is due to the almost zero porosity of the rust preventive film which makes them highly impermeable to the passage of moisture and air through this thin film which, if penetrated, would cause rusting.

Rust preventive compounds are made in various consistencies from hard greases to liquids that can be sprayed. The hard greases are usually melted and the parts dipped in the solution which provides a quick method of complete coverage with a coating that will harden sufficiently to permit handling and shipping. The spray coating which is the compound thinned with paint thinners, white gasoline or kerosene provides a quick and easy method of applying the rustproof compound to machine parts, especially to the inside of the machine or to parts that cannot easily be reached by brushing. A paint spray gun is ideal for this purpose. The thinner rapidly evaporates leaving the rust preventive coating on the metal. The soft grease compounds are very convenient to use because they are easily brushed or swabbed on the parts to be protected, and should give rust protection for a year or more on outside exposed parts. Diluted samples will give protection for three to six months under the same conditions.

In addition to preventing rust on the exposed parts of farm machinery and equipment, rustproof compounds are added to crankcase lubricating oils to give the inside of the engine a rustproof protective coating when put in storage or when shipped overseas. It is logical to predict that as soon as war conditions permit, rustproof compounds will be added to crankcase oils, transmission oils, and lubricants to prevent rusting of the inside parts of the machines in which they are used.

The following discussion is a progress report on tests run by the department of agricultural engineering of the University of Illinois during the past year and a half to determine the rust preventive qualities of crankcase oil, transmission oil, pressure gun grease and axle grease when used on polished surfaces of metal strips and moldboard plow bottoms as compared with the protection afforded under the same conditions by the new rust preventive compounds now on the market.

Two sets of tests were run under outside exposed conditions in which the rust preventive samples were applied to polished

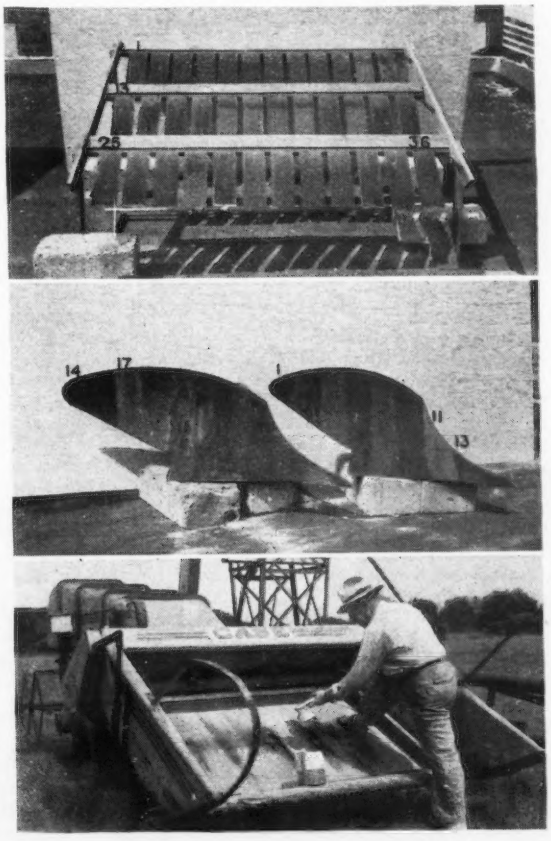


Fig. 1 (Top) Rack in which the 36 polished metal test strips were mounted. The upper 3 in of each strip was left unprotected as a check. Lower 9 in of each strip was covered with rust test samples

• Fig. 2 (Center) Plow bottoms used in test showing the vertical strips of rust preventives. The samples 1, 11, 13, 14, and 17 have given perfect protection for 526 days. The cracking or slipping of some samples allowed early rusting

• Fig. 3 (Bottom) Rust preventive grease should be used on exposed parts of machines standing outside for long periods, but these compounds in diluted form can be sprayed on and will prevent rusting from 3 to 6 months when applied to exposed parts or for a year or more on unexposed parts of machines

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black metal strips 3 x 12 in (Fig 1) and to plow bottoms (Fig. 2). Three inches of the top of each strip was left untreated as a check and the lower 9 in of each strip was covered with one of the various materials being tested. The backs of the strips were treated with the same materials, except that the surface was thoroughly wet with water before the material was applied. A second test was made by painting vertical strips of the compounds on the front surfaces of plow bottoms. Twenty-eight of the 36 samples tested on the metal strips, under outside exposed conditions, were special rust preventive compounds, the other eight samples were crankcase oils, transmission oils, chasse lubes, water pump grease and axle grease.

Difficulty was experienced in locating companies who manufactured rust preventive compounds and also in getting compounds suitable for use on machinery under farm storage conditions. A number submitted definitely were not suited for this particular purpose as is shown in Chart 1.

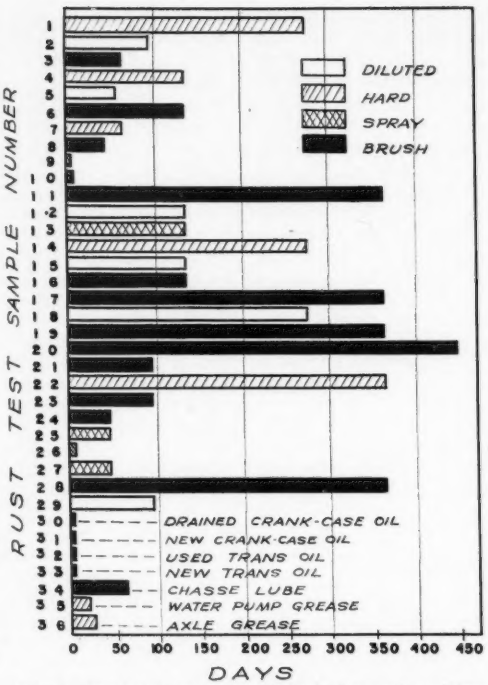

Chart 1. The length of the bars indicate the number of days over which the samples gave rust free protection on polished metal strips. Inspection periods at end of 7, 21, 28, 39, 49, 58, 98, 138, 278, 365, 453, and 479 days

It should be noted from Chart 1, which indicates the performance of the rust preventives tested on the front of the metal strips, that only two of the eight commonly used farm oils or greases used in the test gave protection against rust for more than one month, while three of the special rust preventive compounds gave protection for 278 days, five for 365 days, and one for 453 days. These tests were started in March during a period of heavy rainfall which washed most of the common oils and greases off the metal strips and allowed rusting to start within a few days. The six rust preventive samples listed as diluted, which were thinned down with white gasoline to spraying consistency, gave protection for three to six months. These diluted samples, when tested on the backs of the strips, which would correspond to use on parts of machinery not exposed to the direct action of the sun and rain, were all giving complete rust protection after 551 days. The backs of the strips were covered with the same compounds as the fronts, except that the metal surfaces were wet with water before applying the test samples. Of the same 28 special rust preventive compounds tested on the backs of strips, 22 showed no rusting after 551 days, and the two common chasse lube pressure gun greases showed no rusting during the same length period. It should be kept in mind that pressure gun greases are not intended to be rust preventive compounds and should not be relied upon until thoroughly tested for that purpose.

Fig. 2 shows the two plow bottoms used in the test. Eighteen of the same samples, Nos. 1, 3, 4, 6, 8, 9, 11, 13, 14, 16, 17, 19, 21, 23, 24, 25, 27, and 28, used in the strip test were used on these plow bottoms, and after 526 days of exposure, samples 1, 11, 13, 14, and 17 were still giving perfect rust protection. Samples 16 and 19 cracked slightly and a trace of rusting was observed in some of the cracks. Samples 1, 11, 13, 14, and 17 gave much longer protection on the plow bottoms than on the metal strips.

The following recommendations are made on the basis of this series of tests:

1 That suitable types of grease rust preventive when brushed on metal surfaces will prevent their rusting from 10 to 12 months or more on machinery stored outside and for an indefinite period on machinery stored under cover. The same grease which contains some lubricating properties can be applied to roller and ball bearings with a grease gun where there is danger of rusting while machinery is in storage.

2 That liquid rust preventives when sprayed or brushed on directly exposed metal parts will prevent rusting from 3 to 6 months on machinery standing out-of-doors, and for a year or more on the unexposed parts of machinery left outside or on all parts of machinery stored under cover.

Rust preventive compounds from most of the large oil and chemical companies were included in the tests. However, each company may manufacture a number of rust preventive compounds and the purchaser should be certain that the one he selects is recommended by the company that manufactures it for use on farm machinery under outside storage conditions.

The use of a special rust preventive compound will stop the tremendous losses in machinery rusting now taking place and will save many hours of farm labor spent in getting rusted machinery back into operating condition.

Curing Hay in Mow with Forced Ventilation

(*Continued from page 420*)

season. Nineteen of the samples were from the forced ventilation method and fourteen samples were field-cured hay from the same farm or a near-by farm. The samples from the forced ventilation method showed 31.6 per cent graded U. S. No. 1, 58 per cent graded U. S. No. 2, 5.2 per cent graded U. S. No. 3, and 5.2 per cent was classed U. S. sample grade, whereas none of the field-cured samples graded U. S. No. 1, 21.5 per cent graded U. S. No. 2, 28.5 per cent graded U. S. No. 3, and 50 per cent was classed U. S. sample grade. Analyzing the data further, it was significant that 89.6 per cent of the forced ventilation samples graded U. S. No. 2 or better, whereas only 21.5 per cent of the field-cured samples graded U. S. No. 2 or better.

Finally, the following points of interest stand out for consideration:

1 The acreage of high quality forage is rapidly increasing in the southeastern states.

2 Weather records definitely show that farmers are seriously handicapped in curing hay in the field.

3 Value of the hay crop is greatly reduced because of the losses involved in the field-curing method.

4 The forced ventilation method of curing hay eliminates the hazards of field curing according to results and testimonials of Virginia users.

5 The investment of from 15 to 20c per sq ft of mow area with an operating cost of 60c to $1 per dry ton is a very small sum to pay for hay and labor saved, plus the improved quality of hay obtained by using the forced ventilation method.

6 USDA analysis shows farmers can consistently obtain at least one grade higher quality hay by use of the forced ventilation method.

7 The forced ventilation method requires no special equipment for harvesting and handling the hay.

8 Farmers have records to show that less handling and less labor are required to harvest and cure hay using the forced ventilation method than when it is cured in the field.

9 Farmers have discovered that putting the hay on the drier a few hours after cutting, and spreading it evenly over the duct system as is required by the forced ventilation method, has increased the mow capacity by approximately 50 per cent. Thus the storage problem is minimized.

10 The forced ventilation method can be adapted to the capacity requirements of any farm, large or small, with equally good results.

11 Letters from Virginia farmers using the forced ventilation method definitely confirm their acceptance of this method.

A Logical Modification of the Rational Formula for Runoff from Small Agricultural Areas

By H. B. Roe and C. G. Snyder
FELLOW A.S.A.E. JUNIOR MEMBER A.S.A.E.

THE rational formula $q = C\,I\,A$ [1] which seems to have been almost universally accepted by agricultural engineers for determination of maximum runoff from small agricultural areas has two serious weaknesses: (1) The assumption inferred in this formula that q varies jointly as the first power of both I and A is unjustified, and (2) the selection of the proper value of the coefficient C rests wholly upon the judgment of the engineer in the given case, supported only by some six rather general descriptions of types of watershed.

The only logical assumption as to I and A is that q varies jointly as some power other than unity of each of these factors; that is, the formula should take the form

$$q = C\,I^x A^y \qquad [2]$$

It even seems reasonable that a third variable, the slope, s, may enter into the final formula making it of the general form

$$q = C\,I^x A^y s^z \qquad [2a]$$

With reference to the coefficient, C, considerable experience by various engineers indicates that almost never can two individuals be found to agree within reasonable limits as to the proper value of C for a given case even when the engineers are men of long and varied experience in this class of endeavor. The factor C is really the ratio of the rate of runoff to the rate of rainfall and it has been generally assumed that its true value in any case is probably determined by the topographic and vegetal cover characteristics and the slope of watershed. The influence of each of these factors is indefinite and will differ widely in different cases. The formula will be used by many engineers who have previously had little or no experience with such phenomena. The results are bound to be largely disappointing unless the selection of the coefficient C can be safeguarded by narrowing it down to dependence on more definite factors.

Final and satisfactory improvement of the formula can be accomplished only when a mass of complete storm data, covering many regions and classes of storm, becomes available. The securing of ample and reliable data of this kind is a long-time and expensive problem. Nevertheless some further analysis of the meager data at present available in the light of the criticisms above stated seems justifiable. From this viewpoint, therefore, in order to try to settle, at least to his own satisfaction, the first question above raised, in 1935, Roe made a statistical analysis of the data from the six watersheds on the Murchison farm near Jackson, Tennessee, presented by C. E. Ramser in his paper "Runoff from Small Agricultural Areas" (Jr. of Ag. Res., no. 9, vol. 34, May 1927) and hereinafter referred to as the Jackson watersheds. Owing probably to sharp differences from each other and from the remaining three, in watershed characteristics, watersheds 4, 6, and 7 of this group showed such a lack of correlation that they were dropped from further consideration in that analysis, the final effort being confined to the data on watersheds 1, 3, and 5, which three seemed to be of about the average character of small agricultural watersheds in rolling country.

The statistical analysis resulted in the formula

$$q = 0.324\,I^{1.158}\,A^{1.037}\,s^{0.00} \qquad [3]$$

which then simplifies to read

$$q = 0.324\,I^{1.158}\,A^{1.037} \qquad [4]$$

This formula, which for convenience will hereinafter be called the Roe formula, has a certain advantage over the "rational formula" and it also has certain distinct limitations. It replaces the indefinite C value by a constant for all cases, but it must also be recognized as applying only to watersheds of average agricultural character and of a limited range as to size.

The Roe formula is also open to the criticism that it is based on too meager data from a small number of watersheds in a single limited region. Still its development seems to have established two pertinent facts: (a) that the slope, s, does not enter separately and directly into the formula for maximum discharge from small agricultural watersheds and (b) that the assumption is doubtless correct that the final formula of this character will take the general form of equation [2].

In spite of the difficulty in securing reliable data, during the past two years the authors have made a further study of this problem with the final result hereinafter reported as the Roe-Snyder formula in distinction from the Roe formula earlier mentioned. The study finally has been limited to the only two sources of data made available in sufficiently complete detail to be of value therein.

Sources of Data for Roe-Snyder Formula. The sources of data used are the Jackson watersheds already referred to and certain selected subwatersheds from the North Appalachian Experimental Watershed, near Coshocton in central Ohio, the data for which were furnished us through Hydrologic Bulletins No. 1 for 1939 and No. 4 for 1940, of the Hydrologic Division of the Office of Research, Soil Conservation Service, U. S. Department of Agriculture. The subwatersheds selected, hereinafter called the Coshocton watersheds, are as follows, the data used being from clear-cut *single storms only* of not *less* than a total of 1 cfs (cubic foot per second) runoff, as double storms do not lend themselves to clear-cut analysis:

Watershed numbers	Area of watershed, acres	Number of single storms selected
20	373	27
196	303	31
10	122	10
177	75.6	12

Brief descriptions of the character of these watersheds follow:

No. 20. *Topography* highly dissected and well drained, with steep slopes of moderate length. *Slopes* 5 to 30 per cent with most of area on the steeper slopes, valleys narrow with high gradients. *Erosion* serious, 50 to 75 per cent of top soil removed on all areas except the alluvial and wooded portion, occasional gullies and slips on a small portion of area. *Vegetal cover* mixed, conservation practices on part, 22 per cent woodland, 57 per cent pasture and meadow, 18 per cent cultivated, 3 per cent miscellaneous. Length of main water course, 7400 ft.

No. 196. *Topography* highly dissected and well drained. *Slopes* steep and of moderate length, average steepness 14 per cent. *Erosion* bad, 50 to 75 per cent top soil removed on part not in woodland, occasional gullies on 10 acres. *Vegetal cover* mixed under prevailing agricultural practices, 26 per cent woodland, 44 per cent pasture and meadow, 22 per cent cultivated, 8 per cent miscellaneous. Length of main water course, 4600 ft.

No. 10. *Topography* highly dissected and well drained with steep slopes of moderate length. *Slopes* vary between 6 per cent or less and upward of 20 per cent, mostly 10 to 20 per cent, average about 15 per cent. *Erosion* not very serious, occasional gullies on a very small portion but none of them large, top soil appreciably removed on some small areas, no erosion on 19 per cent. *Vegetal cover* mixed, no farms under crop agreement, 25 per cent woodland, 48 per cent pasture and meadow, 21 per cent cultivated, 6 per cent miscellaneous. Length of main water course, 3400 ft.

No. 177. *Topography* rather uniform, steep slopes, all toward one main watercourse. *Slopes* running very similar to those of No. 10 with an average of 16 per cent. *Erosion* rather bad, 25 to 50 per cent top soil gone, a few gullies and slips. *Vegetal cover* mixed with conservation practices on part, 11 per cent woodland, 36 per cent pasture and meadow, 42 per cent cultivated, 11 per cent miscellaneous. Length of main water course, 2750 ft.

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The soils of the entire Coshocton region are predominantly loams characteristic of the region.

Of the Jackson watersheds, only 1, 3, 4, and 5 are used in this analysis as data are lacking on watershed 2 and watersheds 6 and 7 are very small areas, less than 5 acres, whose topographic conditions are so abrupt as to place them in a class of runoff behavior entirely different from larger areas. Development of a runoff formula to fit such small steep areas must await availability of a much greater amount of data.

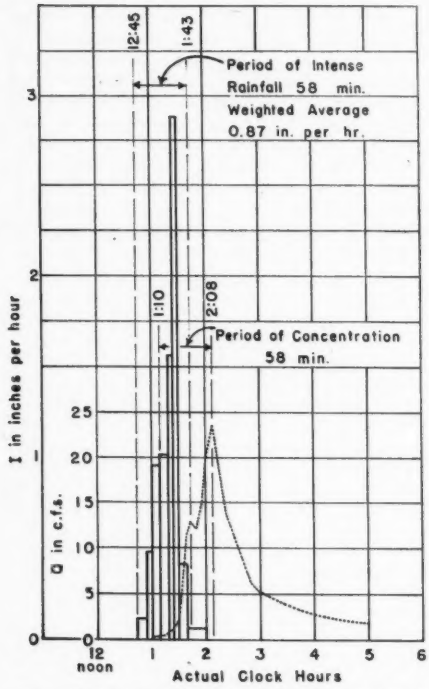


Fig. 1 Hydrograph and rainfall intensity graph for the storm of June 11, 1940, on Coshocton watershed No. 10

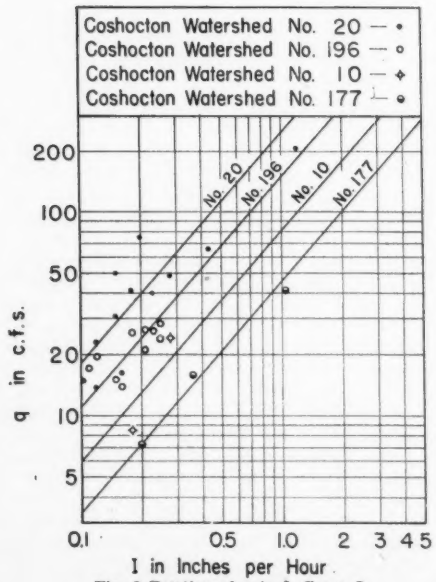


Fig. 2 Relation of q to I, Group I

TABLE 1. DETAILS OF ORIGINAL DATA AND CORRESPONDING DETERMINED AND CALCULATED ITEMS

(In Development of Roe-Snyder Formula for Runoff)

Watershed No.	A in acres	Storm No.	Date of storm	Determined value of I	Values of q Calculated	Values of q Observed	Variation of observed from calculated q Actual variation +	Actual variation −	Per cent variation +	Per cent variation −
GROUP No. 1 ($C = 0.60$, $x = 1.14$)										
Coshocton										
20	373	1	2/15/39	0.23	41.8	45.0	3.2		7.7	
		6	7/ 8/39	0.44	87.7	63.0		24.7		28.2
		9	1/14/40	0.16	27.7	16.3		11.4		41.2
		10	2/10/40	0.15	25.7	30.6	4.9		19.0	
		11	3/ 2/40	0.10	16.1	15.0		1.1		6.9
		12	3/ 2/40	0.12	19.9	23.0	3.1		15.6	
		13	3/2-3/40	0.15	25.9	49.9	24.2		93.2	
		14	3/30/40	0.12	19.9	13.9		6.0		30.1
		15	4/11-12/40	0.18	31.8	41.4	9.6		30.2	
		16	4/19-20/40	0.20	35.8	75.5	39.7		111.0	
		17	4/20/40	0.28	52.3	49.9		2.4		4.6
20	373	26	6/28/40	1.20	275.5	208.0		67.5		24.5
Coshocton										
196	303	2	2/14-15/39	0.25	37.5	28.6		8.9		23.7
		3	2/14-15/39	0.25	37.5	28.6		8.9		23.7
		15	1/14/40	0.16	22.6	14.0		8.6		38.0
		16	3/2-3/40	0.11	14.7	16.2	1.5		10.4	
		17	3/2-3/40	0.12	16.2	19.8	3.6		22.2	
		18	3/2-3/40	0.18	25.8	25.7		0.1		0.4
		19	3/2-3/40	0.21	30.7	26.6		4.1		13.4
		20	3/3-4/40	0.25	37.5	24.0		13.5		36.0
		21	3/3-4/40	0.15	20.9	15.1		4.8		23.0
		23	4/19-20/40	0.23	34.0	26.2		7.8		22.9
196	303	24	4/19-20/40	0.21	30.7	21.2		9.5		30.9
Coshocton										
10	122	2	4/11/40	0.18	10.8	8.5		1.7		15.7
10	122	3	4/19-20/40	0.28	17.1	24.3	7.2		42.0	
177	75.6	1	3/2-3/40	0.20	7.3	7.3	0.0	0.0	0.0	0.0
		5	4/19-20/40	0.36	14.2	16.0	1.8		12.7	
177	75.6	12	9/27/40	1.04	47.4	41.8		5.6		11.8
						Totals			364.0	385.0
						Average of totals			28)	374.5
						Average per cent variation				±13.4
GROUP NO. 2 ($C = 0.36$, $x = 1.14$)										
Jackson										
5	112	1	2/19/18	1.41	59.6	68.0	8.4		14.1	
		2	4/16/18	1.41	59.6	69.0	9.4		15.8	
		4	4/28/18	2.05	91.4	90.0		1.4		1.5
		5	5/ 7/18	2.65	122.4	85.5		36.9		30.1
		6	5/12/18	1.31	54.8	39.4		15.4		28.1
		7	5/23/18	2.36	107.3	120.5	13.2		12.3	
		8	6/ 1/18	2.08	92.9	70.0		22.9		24.7
		9	6/ 6/18	1.20	49.6	56.0	6.4		12.9	
		10	6/ 6/18	1.20	49.6	66.0	16.4		33.1	
5	112	11	7/18/18	2.68	124.0	124.5	0.5		0.4	
Coshocton										
177	75.6	3	3/3-4/40	0.40	9.6	7.9		1.7		17.7
		4	4/11/40	0.20	4.3	5.1	0.8		18.6	
		6	4/19-20/40	0.32	7.4	7.9	0.5		6.8	
		8	6/18/40	2.28	69.6	58.1		11.5		16.5
177	75.6	10	6/28/40	1.83	54.2	50.0		4.2		7.7
Jackson										
3	49.2	1	2/19/18	1.44	26.8	33.0	6.2		23.1	
		2	4/16/18	2.04	39.9	42.5	2.6		6.5	
		3	4/28/18	3.12	64.8	72.0	7.2		11.1	
		4	5/ 7/18	3.24	67.6	58.0		9.6		14.2
		5	5/12/18	1.68	32.0	26.0		6.0		18.8
		6	5/23/18	2.76	56.3	68.0	11.7		20.8	
		7	6/ 1/18	2.64	53.5	39.0		14.5		27.1
		8	6/ 6/18	2.04	39.9	42.5	2.6		6.5	
3	49.2	9	7/18/18	3.00	61.9	80.0	18.1		29.2	
Jackson										
1	20.7	1	2/19/18	2.40	20.3	20.0		0.3		1.5
		2	4/16/18	3.84	34.8	26.5		8.3		23.9
		3	4/28/18	4.44	41.0	38.0		3.0		7.3
		4	5/ 7/18	3.60	32.3	28.5		3.8		11.8
		5	5/12/18	1.92	15.8	16.5	0.7		4.4	
		6	5/23/18	3.12	27.4	32.0	4.6		16.8	
		7	6/ 1/18	3.24	28.6	24.5		4.1		14.3
		8	6/ 6/18	3.00	26.2	29.5	3.3		12.6	
		9	6/ 6/18	2.28	19.2	20.0	0.8		4.2	
1	20.7	10	7/18/40	4.20	38.5	44.5	6.0		15.6	
						Totals			264.8	245.2
						Average of totals			34)	255.0
						Average per cent variation				±7.5
GROUP No. 3 ($C = 0.22$, $x = 1.14$)										
Coshocton										
20	373	4	6/19/39	0.20	13.1	10.3		2.8		21.9
		5	7/ 8/39	0.87	70.0	75.3	5.3		7.6	
		8	1/14/40	0.28	19.2	18.8		0.4		2.1
		20	5/24/40	0.20	13.1	11.2		1.9		14.5
		22	6/11/40	0.58	44.1	45.9	1.8		4.1	
		23	6/18/40	1.58	138.3	121.0		17.3		12.5
		25	6/28/40	1.45	125.4	120.0		5.4		4.3
20	373	27	9/27/40	1.04	85.9	100.0	14.1		16.4	
Coshocton										
196	303	1	2/14-15/39	0.26	14.3	11.6		2.7		1.9
		4	6/18/39	0.60	37.3	25.5		11.8		31.6
		5	6/18/39	0.39	22.8	17.6		5.2		22.8
		6	6/18-19/39	0.51	30.9	30.9	0.0	0.0	0.0	0.0
		7	6/18-19/39	0.27	15.0	19.3	4.3		28.7	
		9	7/ 8/39	1.52	107.5	62.1		45.4		42.2
		10	7/ 8/39	1.02	68.2	47.2		21.0		30.8
		14	1/14/40	0.32	18.1	17.6		0.5		2.8
		22	3/18/40	0.35	20.1	17.6		2.5		12.4
		29	9/27/40	0.76	48.8	39.3		9.5		19.4
196	303	30	9/27/40	0.14	7.1	6.7		0.4		5.6

TABLE 1. *(Continued)*

Watershed No.	A in acres	Storm No.	Date of storm	Determined value of I	Values of q Calculated	Values of q Observed	Variation of observed from calculated q Actual variation +	Actual variation −	Per cent variation +	Per cent variation −
Coshocton										
10	122	1	2/15/39	0.28	6.3	9.4	3.1		49.2	
		5	6/11/40	0.87	22.9	23.6	0.7		3.3	
		6	6/18/40	1.82	53.0	45.3		7.7		14.5
		7	6/28/40	0.50	12.2	17.9	5.7		46.7	
10	122	9	9/30/40	0.42	10.0	9.8		0.2		2.0
Coshocton										
177	75.6	2	3/2-3/40	0.78	12.5	8.6	3.9		36.0	
		7	6/10/40	1.69	30.2	14.1	16.1		53.3	
		9	6/28/40	2.68	51.1	50.0	1.1		2.2	
177	75.6	11	7/23/40	2.83	54.3	44.6	10.3		19.0	
Jackson										
4	15.7	1	2/19/18	1.89	7.2	6.5		0.7		9.7
		2	4/16/18	2.92	11.9	13.5	1.6		13.4	
		3	4/28/18	3.77	15.9	15.0		0.9		5.7
		4	5/ 7/18	3.51	14.6	15.5	0.9		6.2	
		5	5/12/18	1.89	7.2	9.0	1.8		25.0	
		6	5/23/18	2.83	11.5	15.5	4.0		34.8	
		7	6/ 1/18	3.00	12.2	13.5	1.3		10.6	
		8	6/ 6/18	2.14	8.3	9.5	1.2		14.5	
4	15.7	9	7/18/18	3.51	14.6	25.5	10.9		74.7	
						Totals			335.2	367.2
						Average of totals			37)	351.2
						Average per cent variation				±9.5
			GROUP NO. 4 ($C = 0.07$, $x = 1.14$							
Coshocton										
20	373	2	6/18/39	0.68	16.8	11.2		5.6		33.3
		3	6/19/39	0.33	7.4	7.8	0.4		5.4	
		7	10/27/39	1.06	27.9	14.4		13.5		48.4
		19	5/24/40	0.33	7.4	6.0		1.4		18.9
		21	6/10/40	1.24	33.4	51.9	18.5		55.4	
20	373	24	6/23/40	0.72	17.9	26.1	8.2		45.8	
Coshocton										
196	303	11	10/26/39	1.17	25.4	22.1		3.3		13.0
		12	10/27/39	0.90	18.8	32.6	13.8		73.4	
		13	10/27/39	0.47	9.0	13.3	4.3		47.8	
		25	6/12/40	1.50	33.7	20.2		13.5		40.1
		26	6/28/40	1.26	27.6	29.0	1.4		5.1	
		27	6/28/40	1.56	35.2	41.5	6.3		17.9	
		28	7/23/40	2.27	54.0	41.9		12.1		22.4
196	303	31	9/27/40	1.83	42.2	42.7	0.5		1.2	
Coshocton										
10	122	4	6/10/40	1.99	18.6	13.9		4.7		25.3
		8	7/ 8/39	2.37	22.7	29.8	7.1		31.3	
10	122	10	10/26/39	1.58	14.3	10.3		4.0		28.0
						Totals			283.3	229.4
						Average of totals			17)	256.35
						Average per cent variation				±15.1

ANALYTICAL PROCEDURE

Determination of I Values. On the Jackson watersheds Ramser's report furnished all values of both I and A, but on the Coshocton watersheds it was first necessary to determine the value of I in each case by a study of the storm histories. These determinations were made in the following manner, assuming that the period of intensity of rainfall and the period of concentration of runoff were equal to each other in the case of each storm.

The hydrograph of the runoff, in cubic feet per second, from the given storm was plotted on rectangular coordinate paper, and the record of rainfall intensity in the same storm in inches per hour for convenient increments of from 2 to 10 min was superimposed on the hydrograph. It was then a simple matter of careful inspection to determine first the period of concentration of runoff and then the period of intense rainfall of equal length and the average intensity over that period. Fig. 1 is representative of the graphs of this character drawn for each storm of which there were 116 in all. Space limitations in this article do not permit them all to be printed herein. Study of Fig. 1 which is the hydrograph and intense rainfall record of the storm of June 11, 1940, on Coshocton watershed 10 readily shows that the rapid concentration of runoff began at 1:10 p.m. and reached its peak at 2:08 p.m., making the period of concentration of runoff to be 58 min. Then scaling the graph of the rainfall record for that portion of the most intense period preceding the peak of the runoff curve it readily appears that the intense rainfall for that period of time began at 12:45 p.m. and ended at 1:43 p.m. The weighted average of the intensities in inches per hour for the several small increments of time between the two times just above noted can readily be checked and will be found to be 0.87 in per hr, which is the required value of I for the given storm.

The values of I for each storm, thus determined, and used in this analysis are shown for each watershed in Table 1 along with the recorded corresponding maximum rates of runoff. Similar data for the Jackson watersheds are also shown, taken from the data furnished by Ramser.

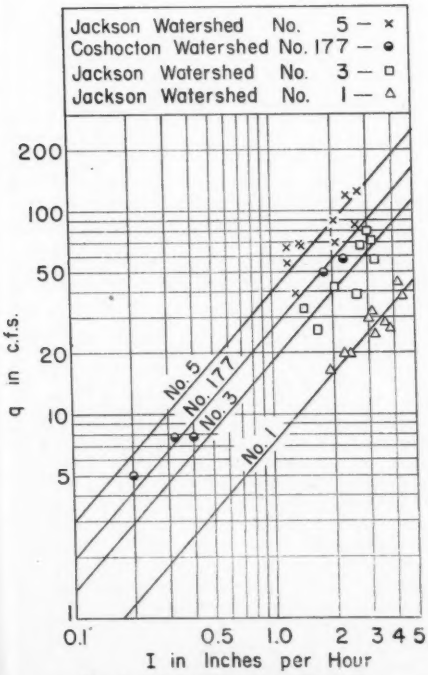


Fig. 3 Relation of q to I, Group II

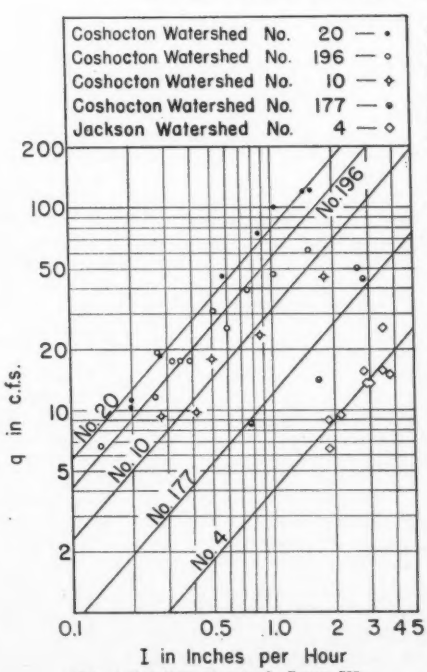


Fig. 4 Relation of q to I, Group III

Determination of the Relation between q and I. The determination of the relation between q and I for each watershed or group of watersheds of similar behavior under storm conditions was then done in the following manner. On double logarithmic paper the observed values of q from Table 1 were plotted as ordinates against the corresponding calculated values of I plotted as abscissas. The result as clearly shown in Figs. 2 to 5 inclusive was a marked tendency for the points to fall into four rather distinct groups according to the intensities and lengths of storm. In each group, for all watersheds, empirical trial indicated that the slope of the average line of relationship was constant with a distinctive intercept value at unit I value for each watershed. The characteristics of the four groups secured roughly outlined as follows:

Group I. Low intensities (for the most part appreciably less than 0.5 in per hr, average 0.27 in per hr). Long storms

(average 114.5 min, the great majority well in excess of 1 hr). Areas of watershed, 75 to 373 acres.

Group II. Moderate to high intensities (for the most part appreciably in excess of 1.5 in per hr, average 2.28 in per hr). Storms from medium length to short (average 38 min, many running from 20 to 30 min). Areas of watershed, 21 to 112 acres.

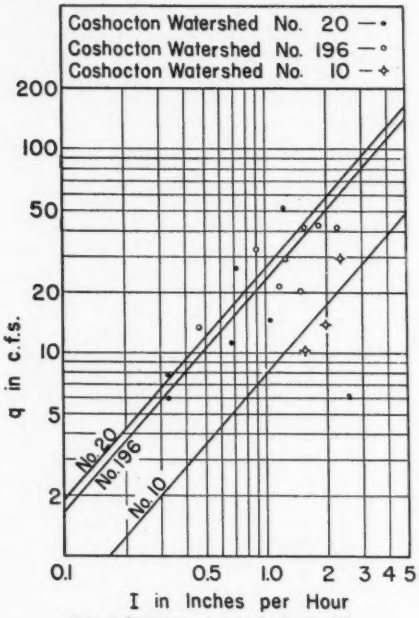


Fig. 5 Relation of q to I, Group IV

Group III. Moderate to low intensities (for the most part appreciably less than 1 in per hr, average 1.01 in per hr). Storms of moderate length (average 51 min, by far the greater number running well in excess of 30 min). Areas of watershed, 75 to 373 acres.

Group IV. Moderately high intensities (for the most part well in excess of 1 in per hr, average 1.25 in per hr). Storms short and sharp (average 33.5 min, many under 25 min). Areas of watershed, 75 to 373 acres.

The mean relationships obtained for each watershed took the general form

$$q = C I^{1.14} \qquad [5]$$

The exact mean value for C for each watershed in each group is as follows:

Group I

Coshocton watershed No.	20; $q = 250.0\ I^{1.14}$; 373 acres	[6]
	196; $q = 151.6\ I^{1.14}$; 303 "	[7]
	10; $q = 82.0\ I^{1.14}$; 122 "	[8]
	177; $q = 45.7\ I^{1.14}$; 75.6 "	[9]

Group II

Jackson watershed No.	5; $q = 40.5\ I^{1.14}$; 112 acres	[10]
Coshocton	177; $q = 26.2\ I^{1.14}$; 75.6 "	[11]
Jackson	3; $q = 18.5\ I^{1.14}$; 49.2 "	[12]
Jackson	1; $q = 7.4\ I^{1.14}$; 20.1 "	[13]

Group III

Coshocton watershed No.	20; $q = 79.3\ I^{1.14}$; 373 acres	[14]
	196; $q = 57.0\ I^{1.14}$; 303 "	[15]
	10; $q = 21.3\ I^{1.14}$; 122 "	[16]
	177; $q = 12.3\ I^{1.14}$; 75.6 "	[17]
Jackson	4; $q = 4.1\ I^{1.14}$; 15.7 "	[18]

Group IV

Coshocton watershed No.	20; $q = 26.4\ I^{1.14}$; 373 acres	[19]
	196; $q = 23.1\ I^{1.14}$; 303 "	[20]
	10; $q = 7.8\ I^{1.14}$; 122 "	[21]

Determination of the Relationship of A to I. It is evident that, if the watershed area affects the value of q, it must be bound up in the q intercept values where I equals 1 in the above equations. Therefore, these q intercept values for each group were plotted on double logarithmic paper as ordinates against the corresponding values of A as abscissas. The resulting graphs (Fig. 6) emphasized still more the falling into the four groups already mentioned, but they also showed quite clearly that, for the data used, A appears in exactly the first power. The resulting equations for each of the four groups are as follows:

Group I	$C = 0.60A$	[22]
Group II	$C = 0.36A$	[23]
Group III	$C = 0.22A$	[24]
Group IV	$C = 0.07A$	[25]

Substituting these values of C successively in equation [5] gives the following final formula for q for each of the four groups:

Group I	$q = 0.60A\ I^{1.14}$	[26]
Group II	$q = 0.36\ A\ I^{1.14}$	[27]
Group III	$q = 0.22\ A\ I^{1.14}$	[28]
Group IV	$q = 0.07\ A\ I^{1.14}$	[29]

In order to determine the practical utility of the foregoing four formulas the values of q for each storm on each watershed, the data from which were used in this development, were computed by these four formulas, each in its proper group. Results compared with actual observed values of q and both the standard percentage deviation and average percentage variation of the observed from the computed values also were determined for each group. These final results are also shown in Table 1.

For those skeptical of the value of the new formula herein presented and who also hesitate to accept the original rational formula, the graphs of actual data shown in Figs. 2 to 5 may prove helpful in selection of probable values of q to fit a given case.

For convenience in using the formulas [26] to [29] inclusive, Table 2, embracing values of $I^{1.14}$ for a considerable range of values of I, is presented.

TABLE 2. 1.14 POWERS OF RAINFALL INTENSITY IN INCHES PER HOUR

I values, in per hr	$I^{1.14}$	I values, in per hr	$I^{1.14}$
0.10	0.072	3.0	3.499
0.25	0.206	4.0	4.857
0.50	0.454	5.0	6.264
1.00	1.000	6.0	7.711
1.50	1.588	7.0	9.192
2.00	2.204	8.0	10.703

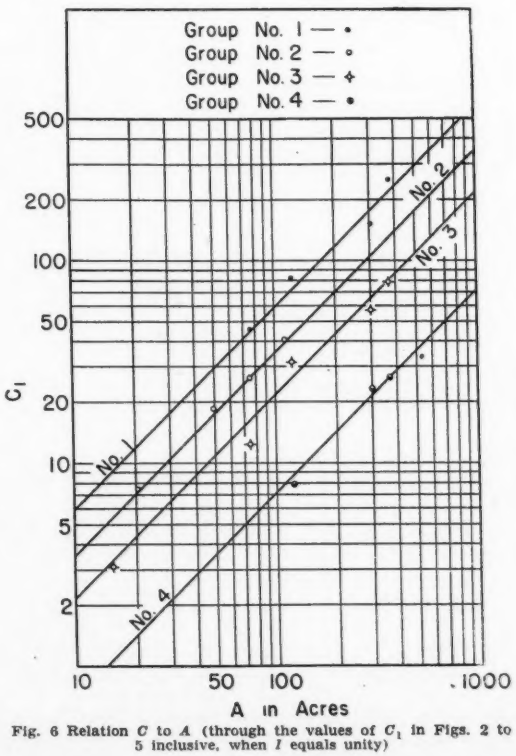


Fig. 6 Relation C to A (through the values of C_1 in Figs. 2 to 5 inclusive, when I equals unity)

CONCLUSIONS

In the application of any empirical formula for runoff from small agricultural areas cases will occasionally occur where the actual observed phenomena differ, for wholly unexplainable reasons, from the theoretical value by formula. However, there were only three out of 119 storms originally considered that deviated so far from the general trends that they were omitted from final considerations and do not appear anywhere in the discussion or in the tables and figures. Still in the main the authors feel that the four group formula herein developed is a more reliable guide than the rational formula in that it leaves less to the untrained judgment of the engineer of limited experience.

It is evident that the value of C is dependent on the length and intensity of the storm rather than on physical characteristics of the watershed. However, it seems clear that no attempt should be made to apply this formula to watersheds smaller than 15 acres or larger than 400 acres until it has been justified by a much greater mass of actual and exact field data than has been available in this development.

Nevertheless it also seems clear that this new formula truly represents the form that any final and generally applicable formula for this purpose must take; but such final formula will not be forthcoming until many times the volume of reliable data now available can be accumulated and used in its development.

Electric Wiring That Meets Farm Requirements

By C. P. Wagner

MEMBER A.S.A.E.

AN economical original farm wiring job is one that has adequate capacity to serve the electrical load which may be brought onto the farm over a reasonable number of years. When we start our wiring system, we know that additional electrical loads are going to develop and that these loads may shift from place to place on the farm. Therefore, an important factor in the economical wiring system is that design will allow changes for increased capacities at the minimum of expense.

Pole metering with the pole in the center of the farmstead and circuits radiating in two or more directions to the various load centers seems to meet the requirements better than any other system. It has the following factors in its favor:

1 Shortest possible runs to any particular load

2 Minimum amount of large wiring in any building

3 Service entrance and metering installation can be changed to larger capacity with almost complete salvage of the previous installation

4 Two or more wires in the overhead system can be changed to larger capacity at a minimum of expense and with relatively high salvage

5 For the farmer who does not desire to spend money for a complete job, this system allows partial installation of wire large enough to serve ultimately a considerable load with the addition of a third wire at a reasonable cost at a later date.

Poles used in the farm wiring system should have the same preservative treatment as those installed by the electric power company.

The most complex and probably the most undesirable system of wiring is one which includes underground service. When such service is installed a much more complete check of ultimate potential loads is necessary and the installation must be made which will carry these loads. If this is not done, we will later find duplicate service in use. Such services are objectionable and expensive. Since this type of service will not properly divide the loads, the system becomes difficult to operate.

Meter services located on houses, barns, or other buildings do, in almost all cases, increase the lengths of service runs to other buildings and complicates the problem of obtaining the most economical and effective farm distribution.

Concealed service entrance at the house is very objectionable since it must be abandoned if we increase capacity; usually the new service entrance is placed outside the walls either in increasing capacity or for new wiring.

In the early stages of our experimental work, we were confronted with servicing machines designed for operation with 400-rpm gasoline engines. These engines, with their relatively large flywheels, of necessity had to be at least 2 hp, and for use with them, milking machines, pump jacks, and other equipment had to be made heavy and substantial. The motors used to replace the engines of necessity were two to four times as large as the motors to do the same work today. It was difficult to obtain wiring of adequate capacity to serve these motors; however, the condition existing called our attention to the fact that we might at any time be called upon to serve relatively large loads at any point on the farm. This brought forcibly to our attention the fact that farmstead wiring must be made flexible.

One great problem of earlier wiring was the entrance switch. The 60-amp type did not have close-fitting fuse clips; thus we had to go to the 100-amp type to obtain reasonable capacity. This was expensive to the farmer. Invariably farmers tell us they are glad they bought good capacity wiring.

Twenty years ago the farm rate was in a transition period. Our companies were trying to serve farmers on their city rate base. Meters were not temperature corrected or compensated for loads from minimum to maximum. Therefore, meters serving lighting and small equipment load would fail to register a considerable amount of the service rendered if they were large enough to serve the larger loads which might be expected on a farm. Power companies found it necessary to establish almost universally a base of limiting the largest motors to 5 hp on a single-meter farm load, since this clause was also in effect on the residential service in towns. The same rules exist today for the hundreds of power companies serving rural areas with the density of load which will permit the use of the urban residential rates. They can not allow the farmer to use power on such rates in larger units than those allowed in the urban residential area. This may be unfortunate since a 5-hp motor is not the most economical unit for general farm machinery operation.

Our studies reveal that at optimum speed most of the heavier farm machinery — feed grinders, ensilage cutters, etc. — operates between 2½ and 3 hp at no load. Most of these machines are most effective when operated at optimum speed using a 7½-hp instead of a 5-hp motor. The added cost for the wiring system to carry this larger motor is very little more than the cost to carry the smaller motor. Failing to operate equipment with a 3-hp motor, the farmer should go to 7½ hp in almost all cases.

Perhaps one of the greatest problems of the future, and a problem which has given considerable difficulty recently, is the establishment of a system to carry equipment which normally operates at 120 volts. Electric brooders is the best example. Getting a three-wire system to the distribution center and balancing the load across the three wires is quite a difficult problem. A single brooder has no more load than a flat iron. This complicates the farmer's mental attitude toward rendering correct service to a group of brooders.

We recently had a layout of brooders on a turkey farm which required a 1/0 wire for the main line and No. 10 wire to each brooder connection point, 120-240 volts to be carried to every brooder connection point. It was quite difficult to show the farmer the need for such large wire. Fortunately the heating rate permitted the use of a separate meter which materially simplified the system as compared with connecting this service to the farmstead wiring.

In Minnesota we have service agencies assisting in the development of better farmstead wiring practices and principles. (At this point in the presentation of his paper, Mr. Wagner displayed copies of "The Minnesota Farmstead Wiring Regulations" with War Emergency Supplement and the "Farmstead Wiring Specifications

Paper presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1943. A contribution of the Rural Electric Division.

C. P. WAGNER is manager, farm service department, Northern States Power Company.

and Proposal".) The wiring specifications and proposal has been in use quite a number of years. Many thousands of copies of this form have been used. Power companies and the Electric Wiremens Association sponsoring this form early eliminated one of our problems, namely, the under-cutting of bids. When each contractor renders his bid on the same form, the customer has a chance to see what is left out of each bid, and the man who does undercutting must usually show the customer that the difference in two prices is fully justified.

The Minnesota farmstead regulations lists the cooperating agencies backing them. Under our state law the State Board of Electricity has charge of licensing master electricians and journeymen. Every master electrician must give a performance bond and must furnish an affidavit that he has completed the job in accordance with code and the farmstead wiring regulations. The Inspectors' Association meets monthly for about nine months of the year and after each meeting it mails out a memorandum covering the discussions and decisions. This memorandum goes to each of the wiremen. We are, therefore, in excellent position to keep up to date and to render best of service to the customer.

The Minnesota Electrical Council takes into its membership any electrical dealers or contractors who may operate in any particular region of the state. The Council has frequent mailings of information which will assist the wiremen or dealers in developing or bettering their business.

On REA projects, inspectors are approved by the State Board of Electricity and get their income from inspection fees. On private power company projects, the same condition exists, except that as a rule the power company inspector checks the wiring system for compliance and at the same time reports the job for construction. In consequence this inspector gets paid by the power company.

There are a few rules where we vary from the National Electric Code. As early as 1921 the author discovered that grounding the farmstead electrical system to any part of the farm water system was very objectionable to persons. With low voltage the charge may be local, but if a transformer breaks down the charge carries through to the entire system, invariably to the drinking cups or other parts of the water system from which the animals are drinking, and usually animals are killed. With low voltage, the charge may be local, but if this happens to be in the barn where, for instance, the milking machine motor breaks down, the charge will be carried onto the stanchions and then to the water cups and invariably cattle are killed. Fortunately a large percentage of milking machines use a belted drive with a wood base on which the motor and vacuum equipment are mounted. Therefore, the broken down motor gives no difficulty. On the other machines with the motor direct connected, the charge is carried to the machine, then to the drinking cups. As a cure, we recommend that the vacuum pipe be cut, two or three inches removed, and a connection be made with a hose which does not have a metal lining. It has been found that grounding the motor is not adequate protection.

For other grounds on the farm, we very definitely recommend driven grounds which comply with the Code. For protection against high voltage of any kind which might be brought onto the farmstead, we recommend that these driven grounds be several feet away from any water system pipe.

We also recommend that no portion of the electrical system parallel the lightning rod system, unless there is considerable separation.

The Minnesota Farmstead Wiring Regulations provide for a 3 per cent voltage drop, also that motor circuits may have 5 per cent regulation. Since the transformer and service drop are likely to have the regulation of 2½ or 3 per cent at full load for the largest motor on a farm and since these larger motors are likely to be overloaded as much as 100 per cent on variable loads, it is quite apparent that all wiring should be on a 3 per cent base.

In the "War Emergency Supplement" of the Minnesota Farmstead Wiring Regulations a 6 per cent regulation is allowed. It is obvious that farms wired with a 6 per cent regulation will have to be rewired at some later date. Fortunately there is very little heavy power installation (5 and 7½-hp motors) going in on farms at the present time.

It is obvious that with proper forethought, methodical planning, and considerable sales work with the farmer, and centralized guiding of the wiremen, the electrical wiring system installed on the farm can be made flexible, and ultimately the farmer will not have spent too much in getting a good wiring system.

In Minnesota we owe much to those agencies sponsoring the farmstead wiring regulations and the distribution of information to those people who do farmstead wiring. The farmer has been protected and usually has a better wiring system than he otherwise might have had.

This paper has not undertaken to cover wartime restrictions as they do not materially affect the general plans. With the wire allotted and the wire unfrozen from retail dealers' stocks we seem to be able to obtain the general requirements of good wiring to the limit of the farmers' present needs. With a planned system in use we are building towards the permanent system with adequate capacity for the usage expected for several years.

It Shells Beans

TO THE EDITOR:

IN May 1942, R. B. Gray and D. M. Crooks of what is now the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, came to Knoxville to study the castor bean sheller shown in AGRICULTURAL ENGINEERING for June 1942. They were pleased with its performance and asked us to develop a similar machine of greater capacity, whereupon H. A. Arnold of our staff designed and constructed a sheller with 24-in disks having a capacity of 25 to 30 bu of shelled beans per hour.

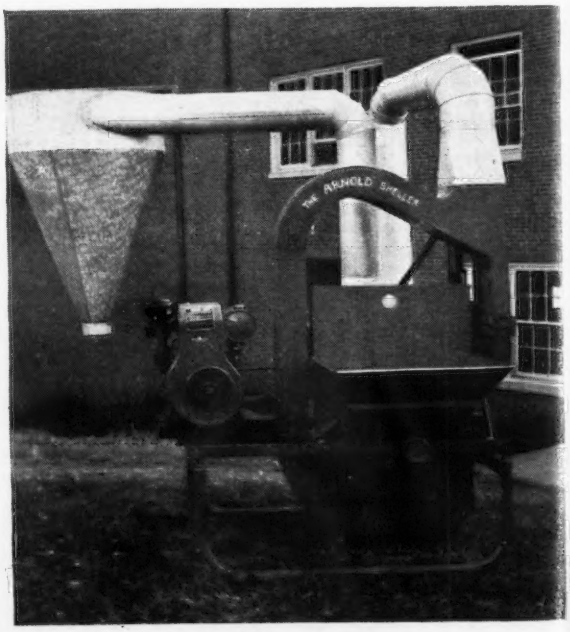
The results were so satisfactory that the Commodity Credit Corporation purchased five of the machines made by a local firm under our supervision with final inspection by the Tennessee Valley Authority. They were used in the CCC seed production program last year and are being used again this year. All reports indicate they are easy to operate and are giving satisfactory service.

There are only two moving parts on this machine. One disk rotates to shell the beans, and a suction fan elevates and cleans them. The shells and light beans are pulled up and out, where they may be collected if desired, as with the machine shown in the accompanying illustration. The clean beans drop down against an air blast into a bagging attachment. One man operates it.

A circular giving directions for building and operating this sheller is being printed by the Tennessee Agricultural Experiment Station and will be available soon.

M. A. SHARP

Head, agricultural engineering dept., University of Tennessee



The Arnold Castor bean sheller

The Relation Between Compressor Size, Insulation Thickness, and Eutectic Values in Farm Freezer Cabinets

By P. T. Montfort

MEMBER A.S.A.E.

EQUIPMENT for freezing and storing the family food supply on the farm is in the development stage and as yet no definite design factors have been established. We know the thermal capacities of refrigeration equipment of various sizes when operating under a given set of temperature conditions. We know the heat conductivity and transmission factors of materials used for refrigerator cabinet construction and for the various foods to be processed. We do not yet know the exact specifications of the job to be done nor do we know the most economical combination of equipment required.

This paper is not intended to be the final answer to the problem, but may contribute a few considerations which will be helpful.

The function of farm freezing and storage equipment, whether it be a separate unit or a built-in compartment in an above-freezing refrigerator is entirely different from the average commercial refrigerator to which we are accustomed. The product and service loads are small. In most cases the average amount of food frozen and stored will not exceed four or five pounds per day. The doors will not be opened more than once or twice per day. On the other hand, there will be relatively large peak product loads perhaps two or three times per year when a beef or several hogs may be killed.

There has been some thought given to the use of frozen eutectic solutions to store "refrigeration" inside the freezer cabinet. (An eutectic solution has a certain concentration at which the freezing point is lowest.) This stored refrigeration is utilized at times of peak product load to supplement the output of the compressor unit. This makes possible the use of a smaller compressor than would otherwise be necessary to freeze the product within the desired time limits.

The "holdover" capacity of the frozen brine also serves as insurance against food losses in cases of equipment failure or power outage.

The determination of compressor size, thickness of insulation, and capacity of eutectic storage for the most efficient operation of a farm freezer is complicated by a number of variable factors such as (1) cost of materials and equipment, (2) cost of fabrication, (3) mean annual and peak ambient temperatures, and (4) annual and peak product loads.

For the purpose of this paper the following conditions are assumed:

1 Net storage space in the freezer cabinet, approximately 26 cu ft
2 Inside dimensions, 24 in deep, 76 in long and 30 to 41 in wide. The width is varied to accommodate coils and brine tanks
3 The cabinet will be fabricated in a local wood-working shop or by a local carpenter
4 A mean annual ambient temperature of 70 F
5 A peak ambient temperature of 100 F
6 An average refrigerant temperature of −15 F
7 An average box temperature of 0 F
8 An annual product load of 1500 lb of meats, fruits and vegetables
9 A peak product load of 350 lb of beef at 60 F—cut, wrapped, and placed in the box so that it may be cooled and frozen to a temperature of 0 F in 24 hr
10 A "service" load of 800 Btu per day.

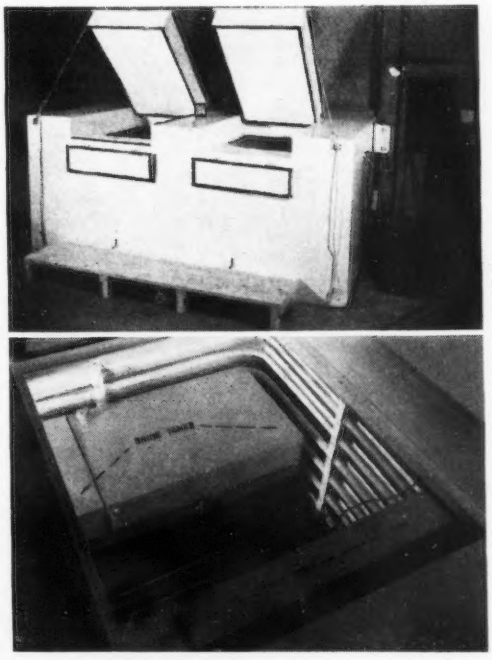
In calculating the heat load through the walls two cabinets with slightly different inside dimensions are used. Cabinet designated as No. 1 has inside dimensions of 24 x 30 x 76 in. A "box" coil of ½-in iron pipe requires a 2-in space along the sidewall and ends. This leaves a net storage space of 26.2 cu ft. The inside dimensions of the cabinet designated as No. 2 are 24 x 41 x 76 in. With the same type box coil and brine tanks 3 in thick along front and back walls, the net storage space is approximately 26.2 cu ft.

Increasing the amount of insulation in a refrigerator cabinet increases the first cost, the depreciation, and the interest on the investment. It decreases the costs of refrigeration equipment and power. For the purpose of this study, four wall thicknesses are used — 5, 7, 11, and 15 in. The insulation thicknesses are 4, 6, 10, and 14 in. The remaining inch includes the inner and outer surfaces of moisture-proof plywood or equivalent and the vapor barrier of asphalt and building paper.

TABLE 1. SURFACE AREAS OF CABINETS NOS. 1 AND 2

Wall thickness, in*	Inside surface area, sq ft	Outside surface area, sq ft	Mean surface area sq ft
	Cabinet No. 1 — Inside dimensions, 24 x 39 x 76 in		
5	67.0	107.2	87.1
7	67.0	125.2	96.4
11	67.0	158.4	112.7
15	67.0	213.1	140.1
	Cabinet No. 2 — Inside dimensions, 24 x 41 x 76 in		
5	82.4	125.8	104.1
7	82.4	145.2	113.8
11	82.4	188.7	135.6
15	82.4	237.3	159.9

*Insulation thickness, 1 in less.



(Top) Experimental farm freezer chest (Cabinet No. 2) with gross storage space of 42 cu ft, or 26.2 cu ft net. (Bottom) Interior view of chest showing arrangement of brine tanks and ½-in iron pipe coil

Heat losses through the walls of large commercial and industrial refrigerated rooms are usually calculated on the basis of outside surface area. In smaller walk-in or reach-in cabinets, the mean of inside and outside surface areas is frequently used. More complicated formulas are available for a more exact calculation if needed. The basis of "mean areas" provides a factor of safety since it indicates a greater heat transfer than actually occurs, especially with small cabinets having thick insulation.

Table 1 shows inside, outside, and mean surface areas of cabinets No. 1 and No. 2 with the four different wall thicknesses.

Table 2 shows the heat losses through the walls of both boxes with the various wall thicknesses.

Table 3 shows the increase in over-all cost of the cabinet as a result of increasing the amount of insulation. Low cost insulation (3c per fbm) is used. If higher priced insulation, say, at 10c per fbm were used, the extra cost of adding 2, 6, and 10 in of insulation to cabinet No. 1 would be $6.03, $28.23, and $80.41, respectively, instead of the values shown in the table. The extra cost of cabinet No. 2, with the higher

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943. A contribution of the Rural Electric Division.

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TABLE 2. TOTAL HEAT LOSSES THROUGH WALLS
(72 F and 100 F Temperature Differentials Between Cabinet and Outside Air)

Wall thickness, in*	U factor†	Total heat transfer‡	Btu per hr 72° T.D.	Btu per hr 100° T.D.	Btu per 24 hr 72° T.D.	Btu per 24 hr 100° T.D.
			Cabinet No. 1			
5	.063	5.49	395	550	9490	13,200
7	.044	4.24	305	424	7320	10,176
11	.028	3.16	228	315	5470	7,560
15	.020	2.80	200	280	4800	6,720
			Cabinet No. 2			
5	.063	6.67	480	670	11,500	16,080
7	.044	4.98	360	500	8,650	12,000
11	.044	3.80	275	380	6,600	9,130
15	.020	3.20	230	320	5,520	7,690

*Insulation thickness, 1 in less.

†Coefficient of total transmittance (Btu/sq ft/hr/deg F) of composite wall computed on basis of following *K* factors (Btu/sq ft/hr /in/deg F): Insulation, 0.30; plywood and vaporproof material, 0.80; surface coefficients, 1.65.

‡Btu per hr per deg F into entire cabinet, on basis of mean surface area (Table 1).

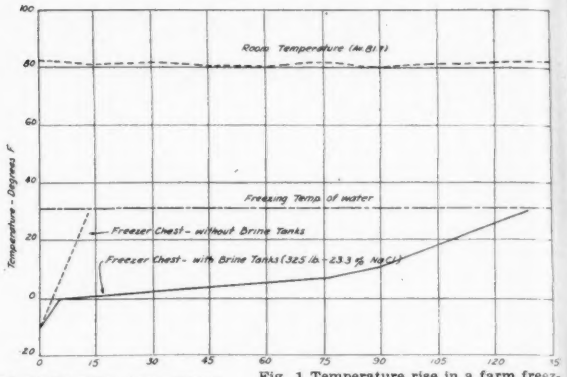

Fig. 1 Temperature rise in a farm freezer chest with power off (16.2 cu ft net storage space; 10 in of insulation)

TABLE 3. EFFECT OF INCREASED INSULATION ON MATERIALS REQUIRED AND FIRST COST OF CABINET (Over basic cost with 4 in insulation)

Insulation added, in	Outside wall sq. ft.	Increase in materials insulation, fbm	Framing, fbm	Outside wall*	Cost of increase Insulation†	Framing‡	Misc. materials	Total
		Cabinet No. 1 - Inside dimensions, 24x30x76 in; 4 in insulation						
2	18.5	19	9.5	$2.22	$0.57	$0.76	$0.50	$4.05
6	51.2	154	21.6	6.15	4.62	2.16	1.50	14.43
10	105.9	530	52.0	12.70	15.90	3.60	2.50	34.70
		Cabinet No. 2 - Inside dimensions, 24x41x76 in; 4 in insulation						
2	19.4	19	8.1	$2.33	$0.57	$1.01	$0.65	$4.56
6	62.9	189	21.9	7.55	5.67	2.87	1.75	17.84
10	111.5	558	35.0	13.38	16.74	4.12	2.80	37.04

*½-in moisture-proof plywood or equivalent, at 12c per sq ft
†Fiberglas bats (red top) or equivalent at 3c per fbm
‡At 8c per fbm

priced insulation, would be $6.60, $34.57, and $85.23, respectively.

Table 4 shows the effect of insulation thickness on operating cost. On the basis of operating cost only, the savings effected by an increase of two inches of insulation above the basic 4 in in cabinet No. 1 would retire the extra investment (Table 3) in 8 months. The extra investment in adding 6 in of insulation would be retired in 16 months, while the extra investment in adding 10 in would require 33 months to be retired. The extra investment incurred in adding 2, 6, and 10 in of insulation to the walls of cabinet No. 2 would be retired in 7, 16, and 27 months, respectively. These calculations are based on the use of low cost insulation (3c per fbm).

TABLE 4. EFFECT OF INSULATION THICKNESS ON ANNUAL OPERATING COST
(70 F mean annual temperature and —15 F refrigerant temperature)

Insulation thickness, in	Heat load Btu/day*	Kw-hr per year†	Power cost per year‡	Annual saving over 4 in insulation	Months to retire additional investment§
		Cabinet No. 1			
4	9490	865	$25.95		
6	7320	670	20.10	$ 5.85	8
10	5470	500	15.00	10.95	16
14	5520	440	13.20	12.75	33
		Cabinet No. 2			
4	11500	1050	31.50		
6	8650	790	23.70	$ 7.80	7
10	6600	605	18.15	13.35	16
14	5520	505	15.15	16.35	27

*Product and service loads not included
†On basis of 4 Btu of heat removed per watt input to motor
‡At 3c per kw-hr
§On basis of costs shown in Table 3.

If insulation costing 10c per fbm were used, then the time required to retire the added investment would be as follows:

	Cabinet No. 1	Cabinet No. 2
2 in insulation added	12 months	10 months
6 in insulation added	31 months	31 months
10 in insulation added	76 months	63 months

TABLE 5. CAPACITIES OF SMALL REFRIGERATOR COMPRESSORS

Size of motor, hp	Btu output Per hr	16 hr	18 hr	24 hr
	70 deg ambient, –15 F refrigerant			
¼	980	15,650	17,600	23,500
⅓	1240	19,850	22,300	29,800
½	2200	35,200	39,600	52,800
¾	3400	54,400	61,200	81,600
	100 deg ambient, –15 F refrigerant			
¼	740	11,850	13,300	17,750
⅓	960	15,400	17,300	23,000
½	1610	25,400	29,000	38,600
¾	2680	42,900	48,300	64,400

The determination of compressor size is affected by insulation thickness, peak product load, peak ambient temperature, and capacity of brine storage.

The compressor should have sufficient capacity to freeze the maximum product load within the desired time. We have assumed these peak conditions to be 350 lb of beef, or equivalent, cooled and frozen from 60 F to 0 F in 24 hr when the outside air temperature is 100 F.

To freeze the 350 lb of beef requires approximately 47,400 Btu. If cabinet No. 1 is used, the total of product and heat loss (Table 2) refrigeration loads will be:

With 4 in insulation	60,600
With 6 in insulation	57,576
With 10 in insulation	54,960
With 14 in insulation	54,120

If no eutectic solution is used, a ¾-hp compressor would be necessary (Table 5).

If cabinet No. 2 is used, the total refrigeration load will be (Table 2):

With 4 in insulation	63,480
With 6 in insulation	59,400
With 10 in insulation	56,530
With 14 in insulation	55,090

If no brine tank is used, a ¾-hp compressor would be needed (Table 5).

There are many substances suitable for making aqueous solutions which will have eutectic temperatures or "points" varying from 28 to –164 F. Since the farm freezer chest will be operated at approximately 0 F, the solution should have a freezing point within a few degrees of this temperature. Table 6 shows the eutectic values of four solutions having freezing points near 0 F. Sodium chloride (common salt) being readily available and inexpensive is used in this study. The other salts in the table will not be generally available until the close of the war.

Each pound of frozen eutectic sodium chloride solution will absorb approximately 125 Btu of latent and sensible heat between –6 and 15 F.

TABLE 6. EUTECTIC POINTS OF AQUEOUS SOLUTIONS

Substance	Eutectic concentration (per cent by weight)	Eutectic temperature, deg F
Ammonium chloride	19.1	- 4.3
Ammonium nitrate	42.8	2.0
Sodium nitrate	39.7	0.6
Sodium chloride	23.3	—6.0

The stored refrigeration in a frozen eutectic solution in the farm freezer chest serves as insurance against food spoilage in case of equipment failure or power outage. These may not occur frequently, but they are important considerations to the farmer who may have 1000 to 1200 lb of frozen meats, fruits and vegetables stored in the cabinet.

(Continued on page 432)

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Farm Freezer Cabinets

(Continued from page 430)

The value of the frozen eutectic in maintaining cabinet temperatures when the compressor is not operating is indicated in Fig. 1. This chart shows the results of an actual test made at College Station, Texas, with a farm freezer chest having a net storage space of approximately 26.2 cu ft with 10 in of insulation, located in an average ambient temperature of 81.7 F. The brine tanks contained 325 lb of 23.3 per cent (eutectic) solution of sodium chloride. One hundred thirty hours (5 days, 10 hours) elapsed before the temperature in the center of the box rose to 32 F. When the test was repeated without the brine tanks, the temperature at the center of the box rose to 32 F in 14½ hr.

TABLE 7. AMOUNT OF SODIUM CHLORIDE EUTECTIC NEEDED TO SUPPLEMENT VARIOUS SIZES OF COMPRESSORS
(350 lb beef; 100 F ambient temperature)

Insulation thickness, in	Total refrig. load (24 hr), Btu*	Capacity of comp. (24 hr)†	Heat to be removed with eutectic	Amount of eutectic needed, lb
		¾-hp compressor		
4	63,480	64,400	None	None
6	59,400	64,400	None	None
10	56,530	64,400	None	None
14	55,090	64,400	None	None
		½-hp compressor		
4	63,480	29,000	34,480	276
6	59,400	29,000	30,000	240
10	56,530	29,000	27,530	220
14	55,090	29,000	26,090	208
		⅓-hp compressor		
4	63,480	17,300	46,180	370
6	59,400	17,300	42,100	336
10	56,530	17,300	39,230	314
14	55,090	17,300	37,790	302
		¼-hp compressor		
4	63,480	13,300	50,180	402
6	59,400	13,300	46,100	370
10	56,530	13,300	43,230	346
14	55,090	13,300	41,790	330

*Includes product and service (800 Btu per day) loads and wall losses into Cabinet No. 2

†From Table 5

Since equipment failure or power outages will probably not extend over the period indicated in the test, the quantity of brine could be reduced, thus providing a larger net storage space in the cabinet. In most cases the quantity of brine will be determined by the size of compressor and the peak refrigeration load.

If a compressor smaller than ¾ hp were used on cabinet No. 2 when freezing the 350 lb of beef at 100 F ambient temperature, it would be necessary to supplement it with frozen eutectic if the meat is to be frozen within the allotted time.

Table 7 shows the amount of eutectic needed to supplement the various sizes of compressors with various thicknesses of insulation.

Table 8 shows the effect of compressor size on annual fixed charges.

TABLE 8. EFFECT OF COMPRESSOR SIZE ON ANNUAL FIXED CHARGES

Size of comp. (hp)	List price*	Increase in first cost: Above smaller size	Increase in first cost: Above ¼-hp	Increase in annual cost†: Above smaller size	Increase in annual cost†: Above ¼-hp
¼	$133.00				
⅓	189.00	$56.00	$ 56.00	$6.70	$ 6.70
½	254.00	65.00	121.00	7.80	14.50
¾	314.00	60.00	181.00	7.20	21.85

*Approximate installed price

†Depreciation and interest at 12 per cent

Table 9 shows the annual operating cost with various sizes of compressors, amounts of eutectic solution, and insulation thicknesses. The calculations for the ¼, ⅓, and ½-hp compressors are based on the wall losses into cabinet No. 2. Since the eutectic solution would not be necessary with the ¾-hp compressor, calculations for this unit are based on wall losses into cabinet No. 1.

On the basis of this study, the most economical equipment is a cabinet with 10 in of insulation, using 346 lb of eutectic solution, and operated with a ¼-hp compressor.

If this refrigerator is to manufactured commercially, there are factors in the fabrication and distribution costs which might materially change the final results.

TABLE 9. ANNUAL OPERATING COST WITH VARIOUS SIZES COMPRESSORS, EUTECTIC VALUES AND INSULATION THICKNESS
(70 deg mean ambient temperature)

Insulation Thickness, in	Amount of eutectic, lb	Annual fixed charges*	Annual operating cost†	Total annual cost
		¼-hp compressor - Cabinet No. 2		
4	402	$40.16	$35.50	$75.66
6	370	40.71	27.70	68.41
10	346	42.30	22.15	64.45
14	330	44.60	20.35	64.95
		⅓-hp compressor - Cabinet No. 2		
4	370	41.90	35.50	77.40
6	336	42.45	27.70	70.15
10	314	44.04	22.15	66.19
14	302	46.34	20.35	66.69
		½-hp compressor - Cabinet No. 2		
4	276	54.60	35.50	90.10
6	240	55.15	27.70	82.85
10	220	56.74	22.15	78.89
14	208	59.04	20.35	79.39
		¾-hp compressor - Cabinet No. 1		
4	None	54.90	29.95	84.80
6	None	56.63	24.10	80.73
10	None	57.12	19.00	76.12
14	None	59.06	17.20	76.26

*Includes annual depreciation and interest on first cost of cabinet and refrigerating equipment at 12 per cent and on brine tanks at 20 per cent. First cost of cabinet No. 2 with 4 in insulation, $105.00. Cost of eutectic tanks and solution, $25.00. Cost of cabinet No. 1 with 4 in insulation, $80.00

†Includes annual product load of 1500 lb. cooled from 70 to 0 F (Average, 150 Btu per lb) and a service load of 800 Btu per day. Electricity at 3c per kw-hr

Dynamite "Power" in Agriculture

WHILE most of the dynamite manufactured in this country is used for industrial construction work, coal and metal mining, and quarrying, about 5 million pounds of this highly mobile and versatile engineering tool are used annually for agricultural purposes.

Some of its uses, such as blasting to stop the spread of forest fires, are of dramatic significance, but most of the accepted uses of dynamite on the farm are for such prosaic functions as land clearing, drainage, irrigation, stump blasting, road construction in lumber camps, and fruit-tree planting.

One of the biggest agricultural uses of dynamite is digging ditches. By the propagation method, it is frequently possible to blow a ditch in marshy swampy land much more quickly and more economically than by any other method. One or more cartridges of ditching dynamite are placed in holes 18 to 24 in apart in the line of the desired ditch. One or two extra cartridges are placed in one of the holes, usually about the center, and one of these is primed with a cap and fuse. When this central hole is fired, the shock of the explosion detonates the charge in holes on each side which, in turn, do likewise to the next ones. The entire line of charges thus explodes at practically the same time. This blows the dirt high into the air and clear of the ditch, leaving it open for the flow of water.

This method is possible only where soil is very wet and free from sand, as sand cushions the shock of the dynamite and prevents transmission of the detonating wave. Where ditches must be made by blasting through dry soil or sand, an electric blasting cap must be placed in each charge, and these caps connected together into an electric circuit and fired by means of a blasting machine. This limits the length of a ditch which can be fired at one time to the capacity of the blasting machine available, whereas ditches up to 1,000 ft in length have been fired with a single cap by the propagation method.

Clearing land of stumps in cutover regions, particularly in the Northwest, has utilized large quantities of dynamite. Most of the cutover timberland in Wisconsin, Michigan, and Minnesota, and in the Pacific Northwest, has been bought by farmers who blast the stumps with dynamite and raise valuable crops.

In some parts of the South, dynamite is used to blow out the rich resinous stumps of the long-leaf yellow pine. Here the stump, rather than the land, is the valuable commodity. These stumps, rich in rosin and turpentine, are sold to distilleries. Since the operators wish to blow these stumps out in pieces, the charge is placed directly in the woody taproot of the stump itself, not in the ground under the stump. *(Continued on page 438)*

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the addresses indicated.

TIME AND LABOR-SAVING EQUIPMENT FOR THE LAYING HOUSE, *D. C. Kennard* and *V. D. Chamberlin*. Ohio Ag. Exp. Sta. (Wooster) Bimo. Bul. 216 (1942). The equipment described is to be made mostly from wood to meet the current scarcity of galvanized sheet metal. A mash feeder for layers is shown in a photograph and described briefly. A trough for drinking water designed to be placed in the partition between two laying-house pens and provided with drainage arrangements to prevent drip spatter from reaching the floor litter, as well as to permit flushing and cleaning, is shown in a photograph and in one cross section drawing. Box nests, of which each compartment accommodates from four to six layers, can be so constructed as to take up only half the wall space required by single nests of the same capacity. Drawings for the construction of 2x4-ft units accompany the description. Ready-made and homemade catching crates are discussed briefly and illustrated, as are hinged panels for catching.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE ILLINOIS STATION. (Partly coop. Ill. Nat. Hist. Survey, USDA et al). Illinois Ag. Exp. Sta. (Urbana) Rpt. 1938. These include notes by E. W. Lehmann, A. L. Young, and R. R. Parks on an increase of nearly 5,000 kw-hr in the consumption of current on a rural line serving nine cooperating farmers; study of septic tank dimensions, by Lehmann and A. M. Buswell; viscosity after hard use as a key to value of lubricating oils, and rubber tires and high compression as a source of new life for tractors, both by R. I. Shawl; dependence of efficiency of terraces upon maintenance, by Lehmann, R. C. Hay, and E. L. Hansen; influence of field and crop conditions on use of smaller combines, by Young and S. M. Elliott; methods of growing and harvesting soybeans, by H. P. Bateman, Elliott, and Lehmann; curtailment of farm building program by decline in farm prices, by W. A. Foster; killing of insects attacking stored grain by drying, by R. H. Reed and M. D. Farrar; factors affecting the quality of stored wheat, by T. Cleaver, W. Ashby, Foster, W. L. Burlison, G. H. Dungan, Farrar, and Lehmann; and lespedeza weed control through cleaning of seed, by C. W. Veach.

HANDLING AND SHIPPING TESTS WITH NEW POTATOES FROM KERN COUNTY, CALIFORNIA, *W. R. Barger, G. B. Ramsey, R. L. Perry,* and *J. H. MacGillivray*. (Coop. USDA). California Ag. Exp. Sta. (Berkeley) Bul. 664 (1942). Most of the commercial stock from this district is washed and shipped in 100-lb sacks. At the peak of the harvest (June), the temperature of the tubers when loaded is between 75 and 90 F. Stock dug and washed in the morning may be as much as from 10 to 15 deg cooler than that dug in the afternoon. Ventilated shipments in June have a temperature of from 65 to 70 deg enroute, with a somewhat lower temperature while crossing the mountains. Refrigerated shipments cool under shippers' rule 240 (initial ice only) to a point between from 45 to 50 deg on the third or fourth day enroute. Potatoes in 100-lb sacks were hydrocooled from 80 to 50 deg in 15 min by passing through a shower of 35-deg water and were carried in perfect condition. A load was precooled with car fans from 80 to 45 deg in 6 hr, but wind from the fans caused surface browning. Severe surface discoloration (browning) of skinned tubers was reduced by refrigeration and was practically eliminated for the 7-day transit period by precooling in ice water. In a comparison of the effect of immediate icing of cars with that of delayed icing, less deterioration occurred with immediate cooling to 50 deg, even though the temperature rose after the fourth day. Poorer results were obtained by slow cooling in which tuber temperature of about 70 deg prevailed for 2 days followed by 50 deg for the remaining 5 days of the test. The sticky skin condition of tubers near the bunkers of cars under refrigeration appeared to develop during the first 3 days enroute while the tubers are cooling slowly under humid conditions and to be eliminated by precooling the tubers in ice water. When tubers infected with late blight were shipped, the size of the lesions increased, but there was no spread of the disease to sound tubers, whether icing at the first icing station or delayed several days. Exposure to wind or hot soil soon after digging increased surface browning in transit. Browning was found to result from the combined effect of excessive drying and of oxidation of cells injured by skinning and is not immediately noticeable.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE PENNSYLVANIA STATION. Pennsylvania Ag. Exp. Sta. (State College) Bul. 414 (1941). A. W. Clyde reports on an increase of plow draft due to parasitical friction, apparently greater in moldboard than in disk plows, and on adaptation of a field gun recoil mechanism principle to the purpose of an automatic tractor release hitch to prevent share breakage in plowing where heavy stones are encountered.

MACHINING AND RELATED CHARACTERISTICS OF SOUTHERN HARDWOODS, *E. M. Davis*. (Coop. Univ. Wis.) U. S. Dept. Agr. (Washington), Tech. Bul. 824 (1942) Four-foot test boards were collected by the Forest Products Laboratory from different sawmills scattered from Virginia to Texas and compared, together with northern black walnut, Central American mahogany, and standard furniture woods. Separate tests for planing, shaping, turning, boring, mortising, and sanding, and for the related properties, steam bending, nail splitting, and screw splitting, covered 50 samples of each species in each test. The machining trials closely followed commercial practices. Numerous samples of each wood were measured for specific gravity, rings per inch, shrinkage, cross grain, warp, and minor imperfections. Data obtained on about 25 woods show that a given species may give good results in some operations, fair in others, and poor in still others. The general utility of a wood must be judged by summing up its properties. These are here reported in statistical form. Some woods are adaptable to several operations, but others require exacting technics for satisfactory results.

CONSERVATION AND BETTER LAND USE FOR OKLAHOMA, *H. A. Daniel, H. M. Elwell, and H. F. Murphy*. (Coop. USDA). Oklahoma Ag. Exp. Sta. (Stillwater) Bul. 257 (1942). The most effective method of controlling erosion was with thick-growing vegetation, especially grass. Native prairie grasses reestablish themselves on eroded land slowly, but this process can be greatly accelerated in central Oklahoma by the use of legumes, such as sweetclover and sericea lespedeza lightly fertilized. During the last 3 yr the production of beef, on formerly useless, abandoned, scrubby oak land, compared favorably with that on the range land. In comparisons of a livestock system, a grain system, and a commercial fertilizer system, the best results were obtained when all crops except lint cotton were fed to livestock and the manure produced returned to the land with additional lime and phosphorus. Land submarginal for cultivation may be more stable and capable of greater returns when put to its most desirable use. For arable lands, terracing to conserve both soil and water, together with crop rotation, cultivating on the contour, and conservation of all returnable organic matter constitute the recommended practices.

SPRAYING EQUIPMENT FOR PEST CONTROL, *O. C. French*. California Ag. Exp. St. (Berkeley) Bul. 666 (1942). The author discusses sprayers and related equipment in considerable detail of design and operating characteristics, explaining the principles of the various devices, their comparative merits and limitations, effects of variation in the mode of operation, etc. Under the head of fundamental mechanics of sprayers are taken up atomization of spray liquid; pump types and their characteristics; pressure regulators; nozzles, guns, and rods; pressure and its effects; pressure losses in hose and rods; and agitation. The topic of portable power sprayers covers engine-powered, power-take-off, and traction-driven sprayers; sprayer tanks; transport trucks and wheel equipment; towers; and mixing plants and refilling equipment. Stationary spray plants are dealt with under the subheads object of the stationary system, pump and mixing plant, piping design, installation of pipe lines, rate of spraying, original cost of stationary systems, and advantages and limitations of stationary spray systems. Discussion of portable pipe line systems takes up objective of portable systems, the portable pipe line, methods of using portable pipe line systems, and merits and limitations of portable pipe line systems. The treatment of air atomizing sprayers includes development and use, types of equipment, and atomizing characteristics of air-type sprayers. Weed sprayers are considered with respect to requirements of equipment, pumps for weed sprayers, and booms and nozzles.

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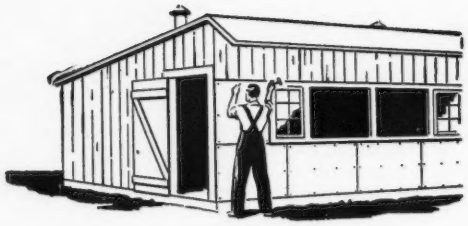

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NEWS SECTION

A.S.A.E. Meetings Calendar

February 1 and 2 — Southeast Section, Henry Grady Hotel, Atlanta, Georgia.

June 19 to 21 — Annual Meeting, Hotel Schroeder, Milwaukee, Wis.

Chicago Section Organized

AT a meeting of twenty-one members of the American Society of Agricultural Engineers in the Chicago area on November 8, it was formally voted to petition the Council of the Society for permission to organize the group as the Chicago Section.

At the business session of these members, the following officers were elected: C. N. Hinkle, Standard Oil Company (chairman); K. J. T. Ekblaw, American Zinc Institute (vice-chairman); and E. L. Hansen, Portland Cement Association (secretary and treasurer).

The program committee of the group consists of J. M. Strasser (chairman), F. J. Zink, and A. W. Farrall.

The next meeting will be held at 6:30 p.m. on February 14, at the Top-of-the-Town Restaurant at 185 North Wabash Avenue, and any A.S.A.E. member in Chicago on that date is invited to attend.

Southeast Section Meets February 1 and 2

IT has now been definitely decided to hold a meeting of the Southeast Section of the American Society of Agricultural Engineers at the Henry Grady Hotel, Atlanta, Georgia, February 1 and 2. The Section officers, who comprise the program committee, have plans well under way for the program to be presented.

Members of the Society whether they reside or not in the area of the Southeast Section, and others who may be interested in the program to be presented, are cordially invited by the Section officers to attend the meeting. AGRICULTURAL ENGINEERING for January will carry an announcement of the program that is being arranged.

Have You Registered with NRSSP?

MEMBERS of the American Society of Agricultural Engineers, who are trained in engineering or the chemical sciences, who have not already registered with the National Roster of Scientific and Specialized Personnel, may wish to do so. It is suggested that they write direct to National Roster, War Manpower Commission, Washington, D. C., and ask for Form No. 100-94.

In the case of members who have already registered, they will be recircularized in the next few months and supplied with supplementary forms so that they can be recoded in accord with the new NRSSP Engineering and Chemical Sciences Check List. So it is requested that they do not write National Roster, if they have done so, but wait to be recircularized with appropriate forms and instructions.

Personals of A.S.A.E. Members

Wallace Ashby recently resumed his former position in charge of farm structures research, division of agricultural engineering, USDA Bureau of Plant Industry, Soils, and Agricultural Engineering, and is located at Beltsville, Md. For a time he served as chief of the farm machinery and supplies section, USDA Division of War Board Services, and more recently as assistant director of the hemp division, Commodity Credit Corporation.

Arthur C. Jacquot was recently appointed senior branch manager of the North Central Washington office of the Bonneville Power Administration. His new work will consist of the management of Columbia River hydroelectric power to important military establishments, war industries, and eventually the agricultural and civilian requirements of the North Central Washington branch of the Puget Sound District. Previous to his appointment Mr. Jacquot was head of the agricultural engineering department at the Utah State Agricultural College.

A. M. Goodman, extension professor of agricultural engineering, Cornell University, is one of the authors of a bulletin on the home storage of vegetables and fruit recently issued by his institution. He is also sole author of a recent bulletin on farm potato storages and their management.

A. V. Krewatch, extension agricultural engineer, University of Maryland, was granted a four weeks' leave of absence to assist the Florida agricultural extension service by supervising the construction of some eight emergency farm labor camps in that state.

(Continued on page 436)

America Needs Your Food and Your Dollars . . . Bigger Food Production Supplies Both

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E. R. Gross, recently accepted a position with the farm structures research section of the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering, and is now located at Hutchinson, Kansas, where he will engage in the grain storage studies being conducted there by the Bureau. He was previously head of the agricultural engineering department at Rutgers University.

R. E. Jezek, one of the USDA agricultural engineers working on the production machinery development in connection with the guayule emergency rubber project, has been transferred to the Russian dandelion emergency rubber project of the Bureau of Plant Industry, Soils, and Agricultural Engineering, and will be located at the Beltsville Research Center, Beltsville, Md.

S. W. McBirney, who has been serving as senior agricultural engineer in charge of production machinery development on the guayule emergency rubber project for the U.S.D.A. Bureau of Plant Industry, Soils, and Agricultural Engineering, was recently transferred, due to termination of the rubber project, to the farm machinery and equipment division of the War Food Administration and is located at Washington, D. C.

W. E. McCune has been transferred from his position as instructor on the agricultural engineering staff of the A. & M. College of Texas to the agricultural engineering division of tse Texas Agricultural Experiment Station.

L. R. Marchant, until recently an executive vice-president of J. D. Street & Co., St. Louis, is now connected with the Quaker Petroleum Co., and is located at Omaha, Nebr.

J. C. Oglesbee, Jr., recently received appointment as extension cotton ginning specialist in the agricultural and home economics section of the USDA Extension Service, and will be located at Atlanta, Georgia. He was previously extension agricultural engineer for the state of Georgia.

Albert E. Powell, formerly assistant in agricultural engineering at Purdue University, on November 1st became senior research fellow in agricultural engineering at Iowa State College.

C. K. Shedd, agricultural engineer, farm mechanical equipment section, USDA Bureau of Plant Industry, Soils, and Agricultural Engineering, who has been in charge of corn production studies in cooperation with Iowa State College, was recently transferred to the farm structures research section of the Bureau and will assist in the corn storage studies at Ames, Iowa.

(Continued on page 438)

Necrology

CHARLES FLOYD CRUMB, SR., engineering supervisor, engineering department, International Harvester Company, passed away September 24, at the age of 58½ years.

Mr. Crumb was a graduate of the Armour Institute of Technology. His professional records following graduation includes one and one-half years on switchboard layouts for the Western Electric Company, and one year of machine design for Link-Belt Company, before joining the International Harvester organization.

In 1904 he entered the employ of what is now the International Harvester Company as a draftsman in the engineering department of the Deering Works. His work was on mowers, but he was later assigned to drafting work on rakes, binders, and other farm implements produced at the Deering Works, until additional lines of machines were added to the production at that plant.

Mr. Crumb progressed at Deering Works to the position of designer and made trips to South America and Australia as the engineering representative of his company when stripper harvesters and so-called combines were being introduced.

In 1927 he was promoted to chief engineer of the McCormick Works of the Harvester Company, and in 1937 was advanced to the position of engineering supervisor with headquarters at the general office of the Company in Chicago. In this position, which he held up to the time of his passing, he supervised engineering at three of the Company's plants producing farm implements.

Due to Mr. Crumb's length of service, the position he held, and the contacts that he made during a useful career, he became well and favorably known to many in the various divisions of the Harvester organization as well as others in the industrial field.

RESEARCH NOTES

(A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.)

IT'S A TOUGH PROVING GROUND

THERE'S hardly a General Motors wheel that isn't whirring exclusively for war.

Yes, the heat's really on. And while we can't tell you how many engines we're building, we can say this. You can find General Motors Diesels from African deserts to Burma jungles—and on the seas between. They're in tanks, trucks, landing and patrol vessels, tractors and many other tools of war.

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War's a hard taskmaster and a tough proving ground. But when the war is won, these enlarged production facilities for war's demands will mean more economical power for a better peacetime world.

New eras of transportation follow in the footsteps of war. Another new era of transportation is assured in the wake of this war. General Motors Diesel Locomotives already are establishing new standards.

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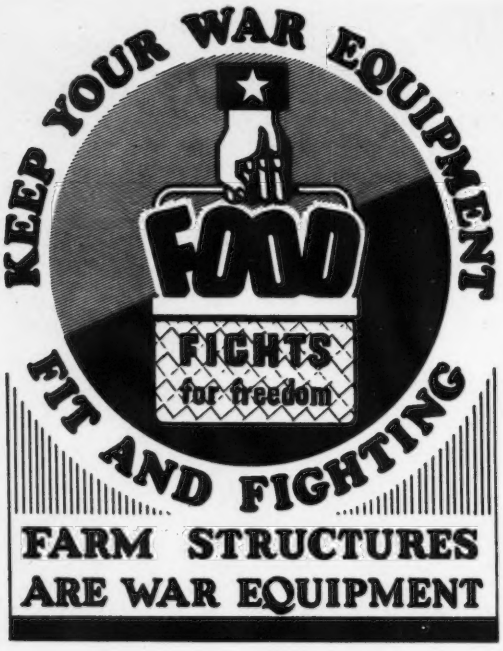

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NEWS (*Continued*)

R. O. Schlegelmilch was recently appointed section chief of the United States Army Signal Corps Liaison Office in Canada representing Camp Evans Signal Laboratory.

Harry H. Steidle for seven years assistant chief of the division of trade standards, U. S. Bureau of Standards, and since 1938 eastern representative of Douglas Fir Plywood Association, has been appointed managing director of the Prefabricated Home Manufacturers Institute recently formed with headquarters at 1244 Shoreham Building, Washington, D. C.

W. J. Welker, until recently one of the engineers working on production machinery development in connection with the USDA guayule emergency rubber project, has accepted a position in the engineering department of the Bean-Cutler Division of the Food Machinery Corporation, San Jose, Calif.

Forrest B. Wright, assistant professor of agricultural engineering, Cornell University, is one of the authors of a bulletin on drying fruits and vegetables at home recently issued by that institution.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Dalton M. Andrews, western manager, Midland Publishing Co. (Mail) 360 N. Michigan Ave., Chicago 1, Ill.

W. A. Davis, assistant editor, Western Construction News, San Francisco, Calif.

S. A. Jones, consulting engineer, 655 Riverside Drive, New York 31, N. Y.

C. W. Lauritzen. soil technologist, U. S Soil Conservation Service, Logan, Utah (Mail) College Hill, Box 170.

Ray C. Miller, president, Miller-Piehl, Inc., Davenport, Iowa.

Cleve H. Milligan, associate professor, Utah State College, Logan, Utah (Mail 711 East 2nd North.

Frank E. Watts, executive assistant, Farm Journal, Inc., 420 Lexington Ave., New York, N. Y.

TRANSFER OF GRADE

Dale I. Cronkhite, mold designer, Goodyear Tire & Rubber Co., Akron, Ohio (Mail) 1194 Juniper Ave. (Junior Member to Member)

P. L. Edwards, manager, Manhattan Rubber Mfg. Co., 445 Lake Shore Drive, Chicago, Ill. (Junior Member to Member)

E. L. Hansen, agricultural engineer, Portland Cement Assoc. (Mail) 1024 Irving Ave., Wheaton, Ill. (Junior Member to Member)

R. R. Jamison, manager, Esco Cabinet Co., West Chester, Penn. (Mail) 205 W. Miner St. (Associate to Member)

Neal G. Preston, district engineer, U. S. Soil Conservation Service, Palouse, Wash. (Mail) Box 375 (Associate to Member)

Dynamite "Power" in Agriculture

(Continued from page 432)

Tree planting with dynamite is profitable for orchards in clay soils. Small charges, ¼ to ½ lb, placed at a depth of about 30 in. are fired when the ground is dry. This loosens the surrounding soil so thoroughly that when the young tree is planted its root growth is greatly facilitated, and the tree often comes into bearing a year or two earlier than those planted in holes not so treated.

Among many other uses of dynamite of interest to agriculture are settling highway fills over soft and marshy ground, a helpful procedure in the speeding up of the building of modern hard-surfaced roads in swampy sections; blasting holes for posts and poles; sinking wells; shooting deep wells to increase the flow of water; increasing drainage by firing subsoil shots between lines of tile drains; starting log jams and blasting ice gorges to release or prevent floods; exterminating mosquitoes by ditching and draining swamps; and controlling forest fires.

The list of agricultural uses of dynamite grows, and so also does our knowledge of explosives and the methods to apply and control their potential energy. Experimentation goes on continually both in the laboratory and the field, and the science of manufacturing and using explosives steadily advances.

DuPont Agricultural News Letter

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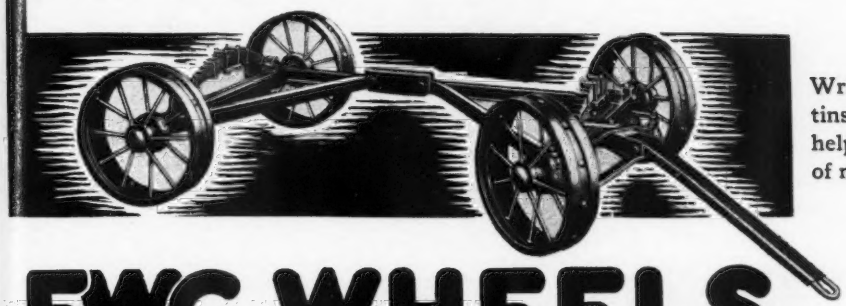

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Larger amounts of Keystone fencing materials are now being shipped to dealers, due to recent goverment releases of steel for fence-making purposes. While it is not extra heavy-coated Red Brand because of the wartime shortage of zinc, it is made of good serviceable galvanized wire, as tightly woven as ever.

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RED BRAND FENCE
and RED TOP STEEL POSTS

Air-Cooled

Check

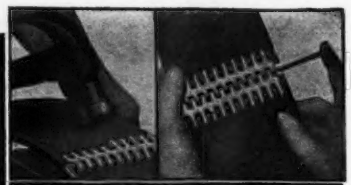
FOR STAMINA AND POWER on Your Equipment!

You want horsepower . . . yes. But over and above that you *must* have STAYING POWER. You get both in Wisconsin heavy-duty air-cooled engines. There's plenty of stamina here for slugging away, day in and day out, on those tough jobs that must be licked on schedule. Wisconsin heavy-duty design and construction can "take it".

Most H.P. per pound

WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

BELT LACING and FASTENERS for transmission and conveyor belts


"JUST A HAMMER TO APPLY IT"

ALLIGATOR
Trade Mark Reg. U. S. Pat. Office

STEEL BELT LACING

World famed in general service for strength and long life. A flexible steel-hinged joint, smooth on both sides. 12 sizes. Made in steel, "Monel Metal" and non-magnetic alloys. Long lengths supplied if needed. Bulletin A-60 gives complete details.

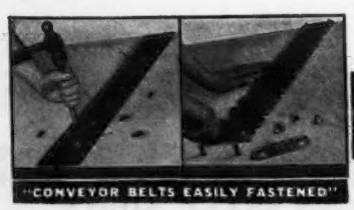
FLEXCO HD

BELT FASTENERS AND RIP PLATES

For conveyor and elevator belts of all thicknesses, makes a tight butt joint of great strength and durability. Compresses belt ends between toothed cupped plates. Templates and FLEXCO Clips speed application. 6 sizes. Made in steel, "Monel Metal", non-magnetic and abrasion resisting alloys.

By using Flexco HD Rip Plates, damaged conveyor belting can be returned to satisfactory service. The extra length gives a long grip on edges of rip or patch. Flexco Tools and Rip Plate Tool are used. For complete information ask for Bulletin F-100.

Sold by supply houses everywhere


"CONVEYOR BELTS EASILY FASTENED"

FLEXIBLE STEEL LACING CO.
4677 Lexington St.
Chicago, Ill.

PROFESSIONAL DIRECTORY

Consulting Engineering Work In Farm Structures Field
Also Sales Engineering for Selected Manufacturers

George R. Shier, A. E.

Member A.S.A.E. Associated with Howard S. Sterner Company, Consulting Structural Engineers, 30 East Broad Street, Columbus, Ohio

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL OR MECHANICAL ENGINEERS wanted by a leading manufacturer of farm machinery. Some very attractive openings are available to engineers who wish to make the design and development of farm equipment their life work. These openings include the design and development of corn, hay, grain, silage, and cotton harvesting machinery. Write giving full details on education and experience. PO-148

ENGINEERS WANTED in our plants in CALIFORNIA, FLORIDA, ILLINOIS and other states. Must have had at least three years' experience in general machine design. Our work is postwar development of machines for use in agriculture and in fruit and vegetable canneries, packing houses, and processing plants. Please give full history, including family, also name of state in which you prefer working, and salary expected — also snapshot of yourself if available. Reply to Food Machinery Corp., San Jose, California.

AGRICULTURAL PRODUCT ENGINEER for mechanical designing and development of corn pickers, combines, and other harvesting machines. Permanent position with old, well-established Midwest manufacturer with national distribution. Located in fine city with adequate housing and educational facilities. Big postwar farm market assures future. Salary open. Write experience, qualifications, draft status, and other particulars in your letter. PO-147

AD COPY WRITER wanted. Man with some technical experience who is creative and has the knack of writing simple, forceful copy for industrial and technical advertising is desired. Permanent position and good opportunity for advancement with long-established 4-A advertising agency. Correspondence will be kept confidential. PO-146

RESEARCH ENGINEER wanted for design and development of agricultural machinery and equipment for the Southeast. Salary up to $3,000, depending on qualifications. Persons interested are requested to write giving full particulars regarding training, experience, and other pertinent information. PO-141.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. S. in both agriculture and mechanical engineering from midwestern university. Some graduate work in engineering. Desires position in college teaching, research, or extension, or with private concern. Has had experience in soil conservation, farm machinery and equipment, farm structures, and rural electrification. At present employed as a state extension agricultural engineer. Farm reared. Married. Age 38. Good reason for desiring a change of position. References and professional record available upon request. PW-357

AGRICULTURAL MACHINERY BLOCKMAN and collector, with three years in agricultural engineering work at Kansas State College, ten years' service with largest manufacturer of farm equipment, two years teaching in national defense training, and one year with farm machinery division of WPB, desires position in industry, or in any branch of agricultural engineering, farm management, or farm machinery design. Age 40, health excellent, no defects or bad habits, married, rural background. Complete credentials furnished upon request. Available October 16, 1943. PW-356

Christmas 1943

It's grim and bleak and terrible for millions of people. Ruin and misery stalk conquered countries. Greed, power, dictatorship and the regimentation of private lives by ruthless governments have blacked out the souls of men.

The contrast with the plain, honest, decent living habits of a free America is appalling — and is making a profound impression on our fighting men.

They are *seeing* and *feeling*, first hand, what the "new order" is doing to Europe. And they are coming home determined that it won't happen here.

They are determined that you and I and the other fellow will continue to elect "public servants"—not masters—and vote them out if we don't like them.

Our American boys are going to decide for themselves what kind of laws they want to live under.

They want a country where everyone gets a decent deal whether he is poor *or* rich. They know America isn't perfect. But they *know* it's better than any other country in the world—and they're going to keep it that way.

When our boys come back, they want an opportunity to work and save and grow—with no government bureau telling them when and where and how to do it.

They want to give their kids an independent education — not one that's controlled by someone with an axe to grind.

American boys have always gone places *under their own power* — and they're going to keep on doing it.

They like the idea that in this country a farmer boy can step into the White House. They take their hats off to the lad in the stock room who grows up to run the business. The ball player who "busts 'em over the fence"— and draws more money than a senator, is a hero in the eyes of millions.

That's America — still the land of opportunity — where hard work, thrift and ingenuity still pay off. And we must never let these precious freedoms slip away.

But to guard them, each of us must be alert. We must take a personal interest in good government—and vote. We must beware of imported political ideas. They didn't work over there—and they won't work over here.

We must educate ourselves and our children in American traditions. We must protect our own personal freedoms—but we must respect the rights of the other fellow. We must work hard—and produce. We must save—and build. We must have faith in our own ability to keep America American.

GIVE
WAR BONDS
AND
STAMPS
FOR CHRISTMAS

REPUBLIC STEEL

GENERAL OFFICES: CLEVELAND 1, OHIO

Export Department: Chrysler Building, New York 17, New York

WOVEN WIRE FENCING • BARBED WIRE • STEEL FENCE POSTS • BALE TIES
ROOFING and SIDING • NAILS • STAPLES • BOLTS, NUTS and RIVETS • PIPE
CARBON, ALLOY and STAINLESS STEELS for FARM and DAIRY EQUIPMENT

His time earned $9 a bushel

Some years ago neighbors kidded a farmer in northern Iowa because he "wasted" two weeks every winter at the state college studying "book farming" while they tinkered around their farms. He came back from one session and planted a field of soy-beans, a crop then practically unheard of. They planted oats and got 30c a bushel for them. He sold his beans for seed at $9 a bushel.

Tell them the value of

FARMING TIME

THE TRUE STORY above is one of many examples of how some farmers have been taught to use their time profitably.

• Today your advice is more important than ever before. Because farmers are faced with the greatest food production task in American history.

• A farmer can produce more food if he spends less time puttering with building and repairing. Other specialists can do these jobs better—leaving him time to concentrate on farming.

DESIGN FOR STEEL

• Right now you may be assisting your farmer friends to plan their 1944 crop and livestock programs. Or you may be helping manufacturers design more efficient farm equipment and buildings—ready to be produced in quantity when war steels can be released for farm use. Many of these products will be made of ARMCO *special-purpose iron and steel sheets* — which are serving so well in silos, grain bins, stock tanks and farm machinery.

• Would you like more information about these special steels? Write for free booklets. . . . The American Rolling Mill Co., 3051 Curtis St., Middletown, Ohio.

BACK THE ATTACK
WITH WAR BONDS

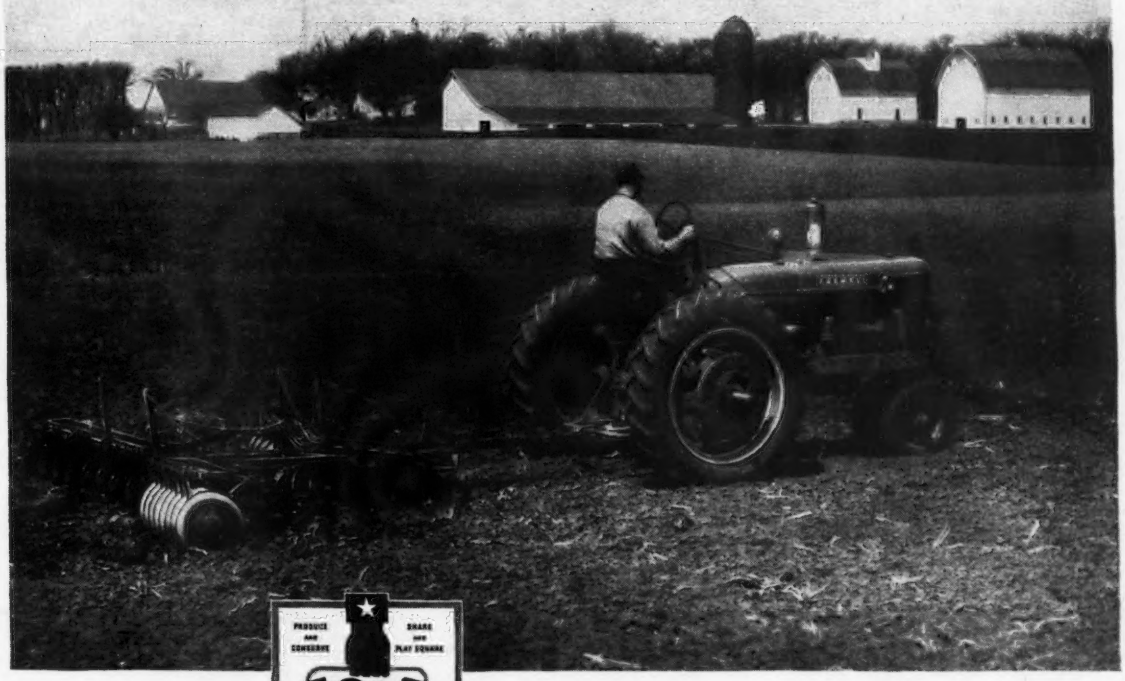
ARMCO

THE AMERICAN ROLLING MILL COMPANY

SPECIAL PURPOSE STEELS
FOR TOMORROW'S FARMING

FARMALL and HARVESTER
ARE PLEDGED TO SERVE
The Family Farm

...and so are the International Harvester Dealers as they celebrate
FARMALL'S 20TH BIRTHDAY



...AND THE FARMALL FIGHTS FOR FOOD!

THE FAMILY FARM is *Home Sweet Home.* It is home ground where every corner in the house, every turn in the lanes, every rise and fall in the fields, is part of the family's heart and soul..

The writer of this Harvester message grew up on the farm. His mother is nearly 80 and she has left the farm for a cottage in town, but her heart refused to come along. The farm is her home, and will be. Her youngest son is operating the homestead now. He is running it alone—with his Farmall tractor. In September he filled his silo, alone—a tough job, but he did it. In the house is Gladys, his wife, and the little daughter, Janet. There will be a new baby in February. "Maybe it will be a boy," they are saying.

Isn't the story much the same on a million farms today? Maybe it is like that on *your* farm.

Everywhere you go, FARMALL Power and hydraulic control of implements makes all the difference. The true all-purpose tractor, that can do so much for a man, is a blessing in times like these. Food is fighting for Freedom—and the Farmalls, with their many mounted, pull-behind and belt machines, are fighting for food.

This Is Farmall's 20th Year—the tractor that *started from the implement end*—the power that is dedicated to the prosperity of the family farm. When the boys come home, the FARMALL SYSTEM will lead the way to the Future!

* *

When war struck our Nation, a Farmall army, with an infinite number of working tools, went into battle. The food crisis was at every farm gate—and the FARMALL SYSTEM was ready.

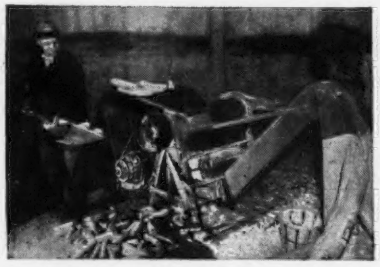
INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue, Chicago 1, Illinois

FARMALL'S 20th Anniversary

★ WARTIME STRATEGY ON THE FARM ★

"Electricity helped me double production without extra hired help!"

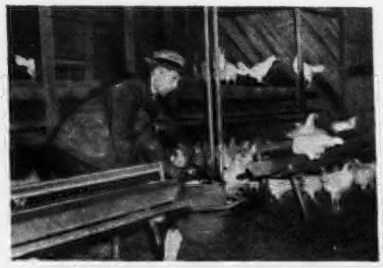
MEET CHARLES F. WENDIG, owner and operator of a *completely electrified* poultry farm near New Hope, Pennsylvania. Read what Mr. Wendig has to say about how *electricity helped him double his production*—in spite of the manpower shortage. Farmer Wendig's story should be of interest to every Agricultural Engineer. We hope you will read it!



CORN SHELLER—"It used to take *two men* an hour to shell 10 bushels of corn with a hand sheller," says Mr. Wendig. "Now, *one man* shells 50 bushels an hour with a sheller driven by a 2 H.P. portable motor. Figuring labor at 50¢ an hour and electricity at 2.5¢ a kilowatt-hour, *we save $4.45 in shelling 50 bushels of corn.*"

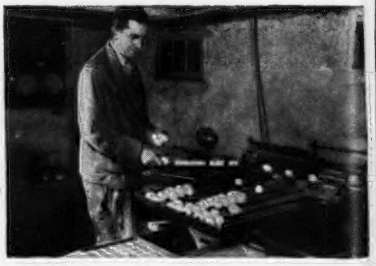
HAMMER MILL—"When we ground feed by tractor power, the fuel cost alone was *$1.20 per ton of feed.* Since we began using this small grinder, driven by a 2 H.P. portable motor, the power cost has dropped to *30¢ a ton.* And that's not the only saving . . . for now our tractor can spend more time at productive work in the fields."

FEED MIXER—"Formerly, we mixed poultry feed by hand—a long, tiresome job—for it took *2 hours* of hard shoveling to mix a ton. Now I mix a ton in *40 minutes,* at a cost of 1¼¢ for electricity. I save 1 hour and 20 minutes of a man's time . . . worth about 66¢ . . . and get a more uniform blend of feed, too!"



LAYING HOUSE—"Electric lights increase our hens' working day and their egg production—there's no question about it! My lights go on automatically about 3 hours before daylight. Personally, I don't think it helps to turn on the lights *after sundown* . . . so our laying houses are dark until next morning."

WATER SUPPLY—"Our 2,000 chickens drink about 100 gallons of water a day. It used to take a man *3 hours* to pump and carry that much water by hand. Now, this electric water-supply system pumps and 'carries' water to all of the automatic drinking fountains for ¼¢ a day. At 50¢ an hour for labor, we save about $1.50 a day."



EGG GRADER—Says Herman Otte, brother-in-law of Mr. Wendig: "When we graded eggs by hand-scale, the most we could do was *100 dozen an hour.* Now, we grade twice as many . . . *210 dozen an hour* . . . for less than a penny's worth of electricity. We get more uniform grading and cut the labor cost in half!"

FREE! "Farm Motors" book and 12 Westinghouse Farm Bulletins, filled with helpful suggestions on how electricity can help cut labor costs and get more farm work done in wartime. Just check the ones you want and mail the coupon, *today!* Westinghouse Electric & Manufacturing Company, Pittsburgh, Pennsylvania.

Westinghouse

Plants in 25 cities . . . Offices Everywhere

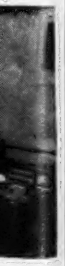
WESTINGHOUSE ELECTRIC & MFG. CO., (Dept. AE-123)
Rural Electrification, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pennsylvania

Please send me free "Farm Motors" booklet ☐—also send free Farm Bulletins on the application of electricity to the subjects checked below:

☐ *Beef Cattle* ☐ *Cooking, Canning, and Preservation of Food* ☐ *Crops*
☐ *Clothing* ☐ *Sheep* ☐ *Handicraft* ☐ *Home Improvement* ☐ *Poultry*
☐ *Rural Electrification* ☐ *Dairy Cattle* ☐ *Swine* ☐ *Truck Gardening*

Name .....

Address .....



One way to *PRODUCE MORE FOOD*

● There are many ways to increase food production, as the ingenious and patriotic Farm Industry has proved.

One way is to keep existing farm machinery running, by careful and expert maintenance methods. OR, to put it in other words . . . to get the maximum number of bushels per anti-friction bearing.

Ball bearings must be properly applied and cared for, if they are to provide the most and best service. That is why we offer you the helpful technical booklets illustrated below. They are free for the asking.

Address your nearest United Motors Service distributor or write direct to New Departure Division of General Motors, Bristol, Connecticut.

3208

NOTHING ROLLS LIKE A BALL

New Departure

THE FORGED STEEL BEARING

a Plus in any Farm Implement Sale

Any farm implement or tractor or piece of farm equipment that is equipped with Timken Bearings is designed, manufactured and can be sold as, a high quality product.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

While bearings or any point of quality are not controlling factors in a farm equipment sale today - - - the day will return when they are once more - - - and stronger than ever.